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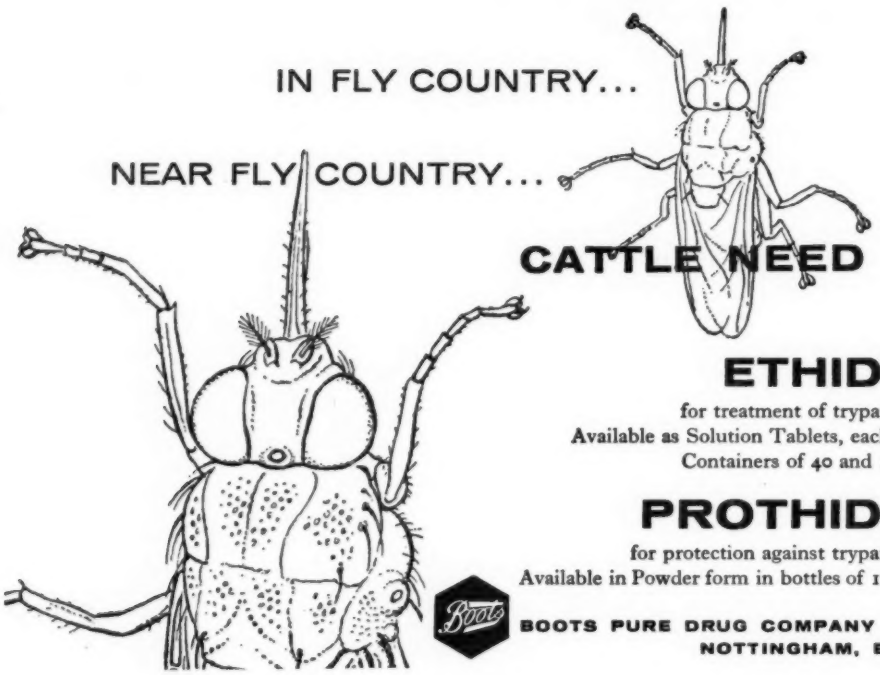

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Congress Papers

Symposium on Disorders of Calcium Metabolism*

(1) Experimental Studies of the Relationship between the Calcium-Phosphorus Ratio of the Diet and Fertility in Heifers: A Preliminary Report

BY

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SUMMARY.—Large-scale controlled experiments carried out at Weybridge in 1958 and 1959 have failed to demonstrate any significant relationship between the Ca:P ratio of the diet and fertility in dairy heifers, whether the level of herd fertility was high or low.

The occurrence of "silent" but fertile heats in some of the younger heifers is recorded.

A high Ca:P ratio depressed growth rate.

There was no relationship between the level of liver copper and either fertility or the intensity of oestrus.

A high intake of phosphorus depressed serum calcium even where the intake of calcium was also high.

Introduction

THE theory that fertility in cattle can be influenced by the Ca: P ratio of the diet appears to have originated in the work of Webster in New Zealand in 1929 and 1930 (Webster, 1932). It has since been considerably developed by Hignett, who has also made observations on the correlation of fertility with dietary manganese. This author has recently reviewed his own and other work in this field (Hignett, 1959; 1960).

Webster's theory was based mainly on clinical evidence. Hignett's elaboration of the theory depends largely on data obtained from small numbers of heifers entering a certain herd over a period of years (Hignett, 1959).

The object of the present experiments was to seek confirmation of this theory under controlled conditions. A preliminary experiment was carried out at Weybridge in 1958 and repeated, with modifications, in 1959. These experiments were intended only to investigate the effects of changes in the Ca: P ratio of the diet on fertility, and no attempt was made to influence the dietary level of any other constituent although the levels of many of these constituents were recorded.

Experimental

Both experiments were extremely simple in design. In the 1958 experiment, 4 groups of 15 heifers each were fed a basic diet similar to that used by Hignett and Hignett (1952) containing a low level of both Ca and P. One group received only this diet. The other 3 groups received mineral supplements containing a large amount of Ca, P, and Ca + P respectively. The animals were maintained on this diet for a period of approximately 2 months, at the end of which time their fertility was assessed by up to 6 artificial inseminations.

In the second experiment, the main differences were that a fifth group of heifers, receiving the rations ordinarily fed to cattle at Weybridge, was added to the 4 groups on the experimental ration, that the heifers were considerably younger than those available in 1958, and that natural service was used instead of A.I.

The relevant details of both experiments are as follows: —

* Symposium of papers presented to the Annual Congress of the British Veterinary Association in Glasgow on Tuesday, August 30th, 1960.

† These experiments were carried out jointly by the departments of Diseases of Breeding and Biochemistry. The following took part in one way or another:—R. Allcroft, K. N. Burns, C. M. Ford, C. N. Hebert, R. D. Lapraik, J. R. Lawson, G. Lewis, A. I. Littlejohn, D. Lornie, J. L. McGirr, A. F. Machin, D. J. MacKinnon, P. G. Millar.

1958 Experiment

Breed. 36 Ayrshire and 24 Friesian heifers.

Source. Four attested herds in Surrey. All heifers were homebred.

Age. Owing to the high standard set for freedom from any infectious disease of the reproductive tract, the number of herds from which heifers could be obtained was small. It was therefore necessary to collect the animals becoming available over a period of nearly 2 years with the result that by the time a sufficient number had been assembled, many of the heifers were well beyond the age at which they would have been mated under ordinary farm conditions. Ages at the start of insemination ranged from 2 to 4 years.

Vaccination. All the heifers had been vaccinated with Strain 19 at between 4 and 19½ months old.

Freedom from infectious disease of the reproductive tract

(a) All the above-mentioned herds were known to have been free from brucellosis, vibriosis and trichomoniasis for a number of years.

(b) Throughout the course of the experiment each heifer was subjected monthly to the serum agglutination test for *Brucella abortus*, weekly to the vaginal mucus agglutination test for *Vibrio fetus* and on 2 occasions (once before and once during the experiment) to the mucus agglutination test for *Trichomonas foetus*. All tests gave negative results except that in the serum agglutination test most of the heifers showed a vaccinal titre of up to 1:40. A few had a titre of 1:80 and 2 maintained a titre of 1:160 throughout the experiment. The latter 2 animals had been vaccinated when between 13 and 14 months of age.

Clinical examination. All heifers were examined *per rectum* 3 times at intervals of one week, well before the start of the experiment. Six were found to be suffering from abnormalities of the ovary (5 cases of cysts and one of hypoluteinisation). Three of those with cystic ovaries were later found to be infertile.

Growth rate. All heifers were weighed weekly throughout the experiment.

Biochemical Estimations

(a) *Liver copper values.* Liver biopsy samples were taken for copper estimation from all the heifers at the beginning and middle of the experiment and from most of the heifers at the end of the experimental period.

(b) *Blood analysis.* Blood samples were taken monthly for estimation of copper, inorganic phosphorus, haemoglobin, calcium and magnesium; blood carotene and vitamin A were also determined twice during the experimental period.

Distribution amongst groups. Division into groups was made primarily on the basis of bodyweight and liver copper levels, so that each group contained an equal proportion of large, medium and small heifers, and of heifers with high and low liver copper levels. Small adjustments were then made to ensure that the few heifers with ovarian abnormalities were equally distributed amongst the 4 groups. Breed was not taken into consideration, nor was age, except in so far as this was reflected in the bodyweight. Soon after the start of the experiment the largest heifer in the Ca + P group developed arthritis of the stifle and eventually had to be slaughtered. The effective number of animals in this group was therefore 14.

Diet

Composition. The diet consisted of the following basic daily ration: —

Oat straw	10 lb.
Sugar-beet pulp ...	7½ lb.
Ground-nut cake	1¼ lb.

This was calculated to provide: —

Starch equivalent	7.5 lb.
Protein equivalent	1.08 lb.
CaO	60 g.
P_2O_5	20 g.

Taking the approximate average weight of the animals to be 1,000 lb., this basic diet provided 6 g. CaO per 100 lb. bodyweight and 2 g. P_2O_5 per 100 lb. bodyweight.

A sufficient quantity of each ingredient was purchased to last for the duration of the experiment in order to minimise the dietary changes arising from variation in composition of successive batches of the different constituents.

Mineral Supplements. Additional calcium was supplied as calcium carbonate and additional phosphorus as anhydrous sodium acid phosphate. The supplements were fed to each animal assuming an approximate average bodyweight of 1,000 lb. On this basis the supplements were so calculated that the total daily intakes of the appropriate groups should be 15 g. CaO per 100 lb. bodyweight and/or 12 g. P_2O_5 per 100 lb. bodyweight.

The groups were as follows: —

		Calculated daily intake in grammes	
		CaO	P_2O_5
I	Basic diet	60	20
II	„ „ + Calcium	150	20
III	„ „ + Phosphorus	60	120
IV	„ „ + Calcium + Phosphorus	150	120

The appropriate supplements were measured individually and carefully mixed with the damp sugar-beet pulp for each animal.

Method of feeding. The oat straw and the ground-nut cake were weighed out separately each day for each heifer. The sugar-beet pulp was measured by volume. It was impossible for any animal to reach her neighbour's ration of sugar-beet pulp or ground-nut cake. In some of the byres, a certain amount of stealing of straw was possible but did not appear to be of frequent occurrence.

The sugar-beet pulp, plus the mineral supplement where applicable, was fed after the morning observation, the ground-nut cake in the middle of the day and the oat straw after the evening observation.

Appetite. The ground-nut cake was invariably eaten with avidity. All but a few heifers cleared up their sugar-beet pulp with equal eagerness. The oat straw was less readily eaten. Wastage was estimated by eye at about 5 per cent. for the majority of the heifers.

Food sampling. This was carried out at approximately weekly intervals throughout the experiment, the samples being taken from the sacks or bales that were to be used during the days immediately following sampling.

Housing

Thirty of the heifers were housed in 2 byres containing 20 and 10 animals respectively, 15 in a range of stalls covered by a roof but open at the back, and the remaining 15 in 7 loose-boxes in which they were tied by the neck, to prevent stealing of food.

For practical reasons the largest heifers were housed in the semi-open stalls and the smallest in the loose-boxes. Atmospheric temperatures were not recorded, but clearly the boxes were warmer than the semi-open stalls, with the byres in an intermediate position. To minimise the effect of this and of any other factor relating to housing, an equal number of animals from each dietary group was housed in each unit.

Detection of oestrus

The heifers were allowed to run in a yard, 15 at a time, for half an hour morning and evening. At first, a vasectomised bull was led amongst them, but as it soon became clear that the manifestations of oestrus in all the heifers were so strong that the presence of the male was unnecessary, the routine use of the bull was discontinued, although he was occasionally required to test a heifer before insemination. These twice-daily observations of oestrous behaviour were made from April 29th until the end of the experiment on December 16th.

Insemination

The bull used was a 3½-year-old Shorthorn, free from brucellosis, vibriosis and trichomoniasis and known to be capable of producing semen of a quality satisfactory by all laboratory standards, under conditions of minimal stimulation, for a period of many months. The fertilising capacity of the diluted semen of this bull was to be checked by inseminating on 3 further occasions any heifers returning 3 times to him with semen from a nominated bull at the M.A.F.F., A.I. Centre at Reading. As will be seen from Table I, only 6 more heifers conceived to 3 A.I's with semen from the Reading bull, indicating that it was not the semen that was responsible for the low conception rate.

From July 7th to September 27th, 43 batches of diluted semen were prepared, at 2-day intervals. The mean volume of the ejaculates was 5 ml. and the mean spermatozoa concentration was just over 1,000 mill. per ml. Within a few minutes after ejaculation, motility was 85 per cent.; at 24 hours it had dropped to 70 per cent. The semen was diluted 1:10, the diluent being egg-yolk citrate in equal parts. Storage temperature was 5° C. Streptomycin and penicillin were added at the rate of 100 microgrammes and 500 units respectively per ml. of buffered diluted semen.

The diluted semen was used on the day of preparation and on the following day and then the remaining volume was kept at 5° C. for a further 3 days to check viability. In each batch not less than 50 per cent. of the spermatozoa were still motile on the fourth day of storage. Each heifer was inseminated twice at one heat period, once during standing oestrus and again approximately 12 hours later. As the semen was collected only every second day, at any one oestrus some heifers received only first-day semen, some only second-day and some, their first insemination with first-day and their second with second-day semen and *vice versa*. Although it was known that second-day semen would be of lower fertility than that used on the day of collection, this was considered to be less disadvantageous than overworking the bull by collecting semen every day over a long period. As will be seen from Table II, however, the conception rate resulting from the use of second-day semen for both inseminations was very low.

TABLE I

1958	Number of heifers conceiving in each nutritional group			
	Basic	High calcium	High phosphorus	High Ca + P
1st insemination	3	5	4	6
2nd "	2	5	5	0
3rd "	3	1	2	2
4th "	2	0	0	3
5th "	0	1	0	0
6th "	0	0	0	0
Total number conceiving to first 3 inseminations	8/15	11/15	11/15	8/14
* Mean fertility rate (first 3 inseminations only)	0·333	0·522	0·478	0·476

1959	Basic	High calcium	High phosphorus	High Ca + P	Weybridge diet (control)
1st service ...	8	10	11	12	11
2nd " ...	4	3	3	1	2
3rd " ...				1	1
Total number conceiving ...	12/12	13/13	14/14	14/14	14/14
* Mean fertility rate	0·833	0·885	0·893	0·917	0·881

*Fertility rate = reciprocal of number of inseminations or services required by each heifer. Animals that did not conceive to any of the first 3 inseminations or services were classified as infertile and given a fertility rate of zero.

Pregnancy diagnosis

Heifers not returning to service by the 70th day were examined *per rectum* and if found pregnant were removed from the experiment. Although then no longer under close observation, they remained at the laboratory until the termination of pregnancy.

Results, 1958

Although, as already mentioned, up to 6 A.I's were given, the fertility of the heifers has been assessed on the results of the first 3 (Weybridge)

TABLE II
1958 EXPERIMENT
NUMBERS OF ANIMALS CONCEIVING TO FIRST 3 INSEMINATIONS, ARRANGED ACCORDING TO AGE OF SEMEN USED

Group	Inseminations*			
	1 : 1	1 : 2	2 : 1	2 : 2
Basic	2/14	4/8	1/3	1/11
High Ca ...	6/13	1/2	1/4	3/11
High P... ...	6/10	3/10	1/4	1/8
High Ca + P ...	5/13	2/5	1/2	0/13
Total	19/50 =38%	10/25 =40%	4/13 =31%	5/43 =12%

* 1 : 1 = Both A.I.s given on day of collection (*i.e.* with first-day semen).
1 : 2 = First A.I. given with first-day semen, second A.I. with second-day semen.
2 : 1 = First A.I. given with second-day semen, second A.I. with first-day semen.
2 : 2 = Both A.I.s given on day after collection (*i.e.* with second-day semen).

A.I's, the second set of 3 (Reading) inseminations being given only as a precaution against possible low fertility in the Weybridge bull.

As will be seen from Table I, there was no difference in fertility between the 4 groups. The level of fertility in all groups was low.

No effect on oestrous behaviour was noted, except that in the high Ca group there was a slight but statistically insignificant lengthening (0.4 days) in the mean inter-oestrous period following the start of insemination.

Compared with the basic group, there was a reduction in the growth rate of the high Ca group and an increase in the growth rate of both the high P and high Ca + P groups. (Table III.)

Copper was stored during the course of the experiment. The mean liver copper value initially was 25.5 p.p.m. per D.M. (Range 3.6 to 130 p.p.m. per D.M.) and after 4 months had risen to a mean of 94 p.p.m. per D.M. (Range 25 to 160 p.p.m. per D.M.). Copper storage was not influenced by the addition of any of the supplements.

Serum calcium levels were significantly depressed in groups III and IV, which received supplementary phosphorus, and it is noteworthy that even in group IV, which received extra calcium as well as phosphorus, mean serum calcium levels remained low.

Blood inorganic phosphorus levels, which were initially in the range 4.0 to 7.6 mg. per 100 ml., fell during the course of the experiment in the basic and calcium-supplemented groups (I and II) and by the end of 6 months were in the range 1.4 to 4.1 mg. per 100 ml., the majority of animals having values below the normal range. Values in the 2 phosphorus-supplemented groups (III and IV) were significantly higher and ranged from 4.2 to 6.6 mg. per 100 ml. at the end of the same period.

Plasma vitamin A levels remained adequate throughout the experiment.

TABLE III
GROWTH RATE
GAINS IN WEIGHT OVER A 21-WEEK PERIOD FROM THE START OF FEEDING OF SUPPLEMENTS

Group	Basic	High Ca	High P	High Ca + P	Weybridge diet
1. *Percentage weight gain over 21 weeks*					
1958	11·5	9·6	14·4	14·3	—
1959	31·6	27·6	33·7	30·6	36·4
2. *Mean weight gain (lb. per week)*					
1958	5·00	4·37	6·64	6·45	—
1959	7·90	6·90	8·48	7·62	9·10

1959 Experiment

Breed. Ayrshire.

Source. Seven attested herds in Hampshire and Berkshire.

Age. 16 to 24 months at the start of service (August 20th) except for one heifer (basic group) which was aged 29 months.

Vaccination. 61 of the heifers had been vaccinated with Strain 19 at between 4 and 22 months old. The remainder were unvaccinated.

Freedom from infectious disease of the reproductive tract

(a) In order to obtain a sufficient number of animals of approximately the same age, it was necessary to obtain most of the heifers from herds of unknown disease history. All, however, were home-bred and were said to be virgin.

(b) The serum agglutination test for *Br. abortus* was carried out monthly throughout the course of the experiment, as before. Apart from one transient reaction (1:40) in an unvaccinated heifer* and the expected falling titre in most of the vaccinated animals, the results were negative. The vaginal mucus was at first tested weekly for agglutinins to both *Br. abortus* and *V. fetus*. One heifer was found to have *V. fetus* agglutinins in the mucus and was at once removed from the experiment. As subsequent vaginal tests of all the remaining heifers were consistently negative, the frequency of mucus examination was reduced to once a month during the preliminary period of observation and was discontinued after the start of service. A single examination of the vaginal mucus of each heifer early in the experiment for *T. foetus* agglutinins was negative.

Clinical examination. As it was considered undesirable to expose the heifers to any stimulus not likely to be encountered under ordinary farm conditions, no rectal examination was made before the start of the experiment.

Growth rate. After being received from the farms in March, the heifers were a little slow in settling down. Although still on an ordinary diet, many failed to gain weight and some even lost weight during the first few weeks. Division of the animals into experimental groups was therefore deferred until all were showing normal weight gains.

*This was the older of the two high Ca heifers that remained anoestrous throughout the experiment.

Biochemical Estimations

(a) *Liver copper values.* Liver biopsy samples were taken from all the heifers for copper estimation, at the beginning and middle of the experiment, and from most of the animals at the end.

(b) *Blood samples* were taken monthly and estimations carried out as in 1958. Vitamin A was not estimated.

Distribution amongst groups. Again this was made primarily on the basis of bodyweight and liver copper level, but the farm of origin was also taken into account.

As 74 animals were available for this experiment, an additional group of 14 heifers (Group V) was formed as a control, *i.e.* to be fed on the ordinary Weybridge diet. The other 4 groups were intended to consist of 15 heifers each, as in the previous experiment. It was not until after the experiment had started that it was realised that 3 of the heifers were freemartins and that another had an imperforate hymen. Although, unfortunately, 3 of these animals were in the basic group (the fourth was in the Ca + P group) it was by then too late to make any rearrangement. The effective number of heifers in each group was therefore: —basic 12, Ca 15, P 15, Ca + P 14 and control (Weybridge diet) 14.

Diet

Composition. The basic diet was composed of the same ingredients as in 1958, *i.e.* oat straw, sugar-beet pulp and ground-nut cake. Again, enough was purchased to last for the whole experiment.

Because the heifers were younger and smaller than in 1958 the daily ration at the start of the experiment was: —

Oat straw	7 lb.
Sugar-beet pulp ...	6 lb.
Ground-nut cake ...	1 lb.

The amounts of these constituents were increased as the animals gained weight until they were receiving the same quantities as the heifers in 1958.

The control group were fed the ordinary rations used for cattle at Weybridge and received daily: —

"Weybridge" cattle nuts ...	3½ lb.
Kale or cabbage	2 heads (approx. 8 lb.)
Hay	approx. 10 to 12 lb.

These ingredients were not weighed individually for each animal but were measured as they would be under farm conditions. Smaller quantities were fed at the beginning of the experiment and increased to the approximate amounts stated above. These amounts were calculated to supply very approximately: —

Starch equivalent	5.4 lb.
Protein „	1.7 lb.
CaO	157 g.
P_2O_5	74 g.

Assuming the average weight of the heifers to be 700 lb. this control diet provided approximately 22.4 g. CaO per 100 lb. bodyweight and 10.6 g. P_2O_5 per 100 lb. bodyweight.

Supplements. Supplements of calcium carbonate and acid sodium phosphate were given as in 1958. The amounts were adjusted whenever the ration was increased so that at each stage the total daily intake on the basis of the average bodyweight of the 4 groups on the experimental diet was 15 g. CaO per 100 lb. bodyweight and/or 12 g. P_2O_5 per 100 lb. bodyweight in the supplemented groups.

Method of feeding. The 4 groups on the experimental ration were fed in exactly the same way as in the previous experiment, so that stealing, where it occurred at at all, was confined to the oat straw. As the heifers that were receiving the ordinary Weybridge diet were stalled in the usual degree of proximity to one another, a certain amount of casual stealing of greenstuff and hay was possible, but the effects of this were minimised by the fact that these animals were arranged in order of size.

Appetite. The ground-nut cake was eaten greedily as before. Some of the smaller heifers were slow to clear up the sugar-beet pulp, but very few of them ever left any uneaten. The oat straw was usually cleared up by the largest heifers, but the medium-sized and smallest heifers generally left a certain amount.

The control heifers (Weybridge diet) showed normal appetite throughout.

Food sampling. Samples of both the basic and the control (Weybridge) diet were taken fortnightly.

Housing

The 4 experimental groups were housed as in the previous year. As it would have been impracticable to avoid stealing of hay and greenstuff if the animals receiving the Weybridge diet had been stalled amongst the heifers on the experimental diet, they were kept in a separate byre, which, however, was adjacent to the other buildings used in the experiment, in which the atmospheric conditions resembled those existing in the smaller (10-heifer) byre.

Detection of oestrus

Each of 5 groups of heifers (4 groups each consisting of approximately equal numbers of animals from each of the nutritional groups, and one group consisting only of the animals on the Weybridge diet) was allowed to run in a yard for 15 minutes, morning and evening, from May 28th to December 10th, 1959. Although a few of the heifers had rather faint heats, and no bull was employed, a period of 15 minutes was found to be adequate, compared with the 30 minutes of the previous experiment. The detection of any change in behaviour depended upon the complete familiarity of the observer with the normal (*i.e.* dioestrous) behaviour of each individual and the absence of all distractions while the heifers were in the yard. To this end, observations were made by the same worker throughout the experiment, and sights and sounds unfamiliar to the heifers were reduced to a minimum by placing a screen across the outside gate of the yard and preventing the approach of other animals or persons to the yard during the period of observation. Any heifer obviously in oestrus was removed after the first few minutes in order not to distract attention from one showing fainter signs.

Under these conditions it was possible to detect

TABLE IV
INTENSITY OF OESTRUS AT TIME OF FIRST SERVICE (1959 EXPERIMENT)

	Number of heifers served	Normal oestrus	Suboestrus	Slight change in behaviour	No change in behaviour
I. Basic	12	12	–	–	–
II. High Ca ...	13	11	1	1	–
III. High P ...	14	14	–	–	–
IV. High C + P ...	14	12	1	1	–
V. Weybridge diet	14	11	1	1	1

No account is taken of length of oestrus (in some heifers it was quite short) or of the number of cycles seen to occur before service. Seven of the heifers, representing each of the five groups, that are recorded as having shown oestrus of normal intensity had not been seen in oestrus before the start of service.

not only subnormal oestrous behaviour but other slight changes in behaviour not usually regarded as being typical of oestrus. The latter changes would not even have been noticed under ordinary farm conditions and the occurrence of oestrus in such animals would probably have escaped detection even under the highly favourable conditions of the experiment if the observer had not happened to notice a slightly blood-stained vaginal discharge, such as commonly occurs about 2 days after oestrus, in one of the 9 heifers that were apparently still anoestrous 14 days after the start of service, *i.e.* 13 weeks after the start of observations. On the assumption that silent heats might be occurring in other animals, vaginal mucus samples from all these apparently anoestrous heifers were examined every 2 to 3 days from that time onwards, with the result that within 10 days typical oestrous changes had been found in the vaginal mucus of one heifer (Weybridge diet) that had shown no change in behaviour whatsoever and in 3 other heifers (Ca, Ca + P and Weybridge diet) in which the changes in behaviour had been slight. (All 4 heifers held to the first service.) The heifer that had originally aroused suspicion (Weybridge diet) and one other heifer (Ca + P) came into subnormal, but easily recognisable oestrus in 20 and 28 days respectively. The remaining 3 anoestrous heifers (see next section) had still shown no change in the vaginal mucus by the time that observations were discontinued, 14 weeks later.

These findings are included in Table IV.

As all the heifers showing silent or subnormal heats were amongst the smallest of their groups, and as 7 other (small to medium-sized) heifers came into oestrus for the first time only during the fortnight preceding the start of regular vaginal examinations, it is probable that these silent heats were the result merely of immaturity and would have been followed (as in the case of the original anoestrous heifer) by recognisable although perhaps faint oestrus. It may also be mentioned that by the end of the first month of observation, less than 50 per cent. of the heifers had been seen to be in oestrus.

Anoestrus

Three heifers remained anoestrous throughout the experiment. One of these, in the high P group, had suffered a severe attack of traumatic reticulo-pericarditis shortly before the start of service, from which she had not fully recovered by the end of the experiment, and is therefore hardly comparable with the other 2 heifers, both of which were in the high Ca group. One was the smallest in the group; the other was the third largest. On *post-mortem* examination in January, 1960, some 5 weeks after observations and vaginal examinations had been discontinued, the high P heifer was found to have a young corpus luteum in one ovary and oestrous mucus in the vagina, whereas the 2 high Ca heifers showed a typical inactive ovary—of normal size but hard, flattened and containing a number of small follicles.

Service

This was begun on August 20th, 10 weeks after the start of the feeding of the complete experimental diet. Three young bulls, 2 Friesian and one Friesian X Ayrshire, were used. All had been bred at the laboratory, and were known to be free from brucellosis, vibriosis and trichomoniasis..

Controlled natural mating was practised throughout. As the duration of oestrus in most of the heifers was known from previous observation, it was possible to time the service so that it occurred at the period of optimum fertility, *i.e.* towards the end of standing oestrus. On one occasion when heat was shorter than had been expected, service was given some hours after the end of oestrus; this service was nevertheless fertile. One heifer which had an unexpectedly long heat was served during oestrus and being still in standing oestrus 24 hours later was served again (by the same bull). Again, this service was fertile. On the first occasion that each bull was used, he was allowed to serve the heifer twice and towards the end of the experiment, when the services were becoming widely spaced, if the bull had not been used during the preceding 5 days, 2 services were given. In all other cases only one service was given.

Where oestrus was silent or poorly manifested, the state of the vaginal mucus was taken as a guide to the stage of oestrus reached. In only one case did the bull refuse to serve such a heifer when presented, but served successfully some hours later.

Most of the heifers stood well, except those having silent heats, but with the smaller heifers it was sometimes necessary for reasons of their safety to use the service crate.

In spite of the disparity in size between the largest bull (No. 1) and the smallest heifers, and the frequent refusal of this bull to use the service crate,

TABLE V
COMPARATIVE FERTILITY OF BULLS USED IN 1959

Bull	Number of heifers served	Number of heifers returning to first service						Conception rate per cent.
		I. Basic	II. High Ca	III. High P	IV. High Ca + P	V. Weybridge diet	Total	
1	22	–	1	–	1	1*	3	86·4
2	22	1	1	–	–	–	2	90·9
3	23	3	1	3	1†	2	10	56·5
Total	67	4/12	3/13	3/14	2/14	3/14	15/67	77·6

* This heifer returned also to the second service (by No. 3) but held to the third service (by No. 2).
† This heifer returned also to the second service (by No. 1) but held to the third service (by No. 2).

the 3 bulls were used in strict rotation during the first 16 days or so of service, the natural tendency to use the smallest bull (No. 3) for the small heifers being carefully avoided. After this the matings were arranged so that by the time all the heifers had been served once, each bull had served the same number of heifers out of each group. At the same time it was endeavoured to ensure that no bull was called upon to serve oftener than once every 12 hours. As 30 heifers came into oestrus during one period of 6 days (August 29th to September 3rd) this was not always easy to arrange. Nevertheless it was only once necessary to require a bull (No. 2) to serve 2 heifers in succession. Both held to this service.

The period of heavy work referred to above had no apparent effect on the fertility of 2 of the bulls, but the other (No. 3) almost certainly became temporarily infertile, as is clear from the fact that every one of the 6 heifers served by him during the first 3 days of this period returned to service, whereas only 2 of the 11 heifers served by the other 2 bulls (one to each) during the same 3 days failed to hold. All 6 heifers returning to No. 3 bull held to a second service by one of the other 2 bulls (see Table V).

Any heifer returning to any bull was served for the second time by whichever of the other 2 bulls had been less recently used, and if a third service was necessary, by the remaining bull. Both of the heifers (one control and one Ca + P) requiring 3 services were therefore served once (2nd and 1st service, on October 1st and 2nd respectively) by No. 3 bull, but as he had successfully served all 6 of the heifers presented during the preceding 4 weeks, it is unlikely that the bull was at fault, although this point could not be checked because as it happened these were the last 2 heifers to be served by this bull.

Pregnancy diagnosis

As in 1958, except that most of the heifers were examined after the 63rd as opposed to the 70th day.

Results, 1959

In general terms it may be said that even without making allowance for the apparent temporary infertility of Bull No. 3, the fertility in all groups was satisfactory and allows an adequate comparison to be made between the 5 groups.

The results given in Table I indicate that there was no significant difference between the groups in the conception rate either to first service or to the first 3 services. It must be noted, however, that both the heifers which remained anoestrous without apparent cause were in the high Ca group. Where oestrus did occur, its intensity did not appear to have been influenced by the diet.

It was again noted (Table III) that growth was retarded in the high Ca group, the growth rate of this group being significantly lower than that of the basic and high P group. The control heifers (Weybridge diet), on the other hand, grew more rapidly than did those in any of the other groups, their increase in growth rate being very significantly higher than that of any other group except the high P group.

There was considerable variation in liver copper values (range 8 to 420 p.p.m. per D.M. mean 92 p.p.m. per D.M.) at the start of the experiment. These were correlated with the farm of origin of the heifers. Animals from certain farms were of low copper status, whereas others had an adequate liver copper level. The average liver copper fell slightly during the course of the experiment—this was the expected trend with growing animals of this age group. The anoestrous heifers and the heifers having silent or faint heat were not amongst those with the lowest liver copper values.

Changes in inorganic phosphorus level were similar to, although less marked than, those of 1958. The blood phosphorus levels of the group on the Weybridge diet (controls) remained within the normal range.

Discussion

The results obtained for both trials show quite clearly that fertility was not affected by the Ca and P content of the diet. In 1959, a considerable imbalance of dietary Ca and P was compatible with high fertility, while the same imbalance was unrelated to the low fertility that was present in all groups in the 1958 experiment.

Although quite fortuitous, the striking difference between the fertility of the 1958 and 1959 heifers makes the 2 experiments complementary. It is not the purpose of this paper to discuss the reasons for this difference in fertility. Whatever the causes they must have affected each nutritional group equally since the greatest care was taken to ensure that conditions were standardised and that the only difference between the groups was the level of calcium and phosphorus in the diet (except of course in the

1959 control group, which received ordinary rations throughout the experiment).

The ground-nut cake and sugar-beet pulp were found to vary little from sample to sample, but in 1958, the oat straw, although it had all come from the same farm, was found to contain 2 different levels of manganese, suggesting that the consignment had come from more than one field. The oat straw used in 1959 was less variable in this respect. In both experiments the manganese content of the basic diet was fairly low, the daily intake being less than 60 mg. per 100 lb. bodyweight. The manganese intake of the control group on the Weybridge diet could be estimated only roughly because of the wide variations found in the hay and greenstuffs. This emphasizes the necessity for frequent and regular sampling before any conclusion can be drawn as to the dietary level of any mineral constituent.

In neither experiment was fertility related to liver copper level. In the 1958 experiment, where fertility was low, the 4 animals with the lowest liver copper values (less than 50 p.p.m. per D.M.) all proved to be fertile. In 1959 fertility was high in animals of much lower liver copper status; 10 animals with liver copper levels less than 25 p.p.m. per D.M. conceived, 9 of them to the first service. The animals that were anoestrous throughout the experiment were not of low copper status.

The phosphorus content of the basic diet (which provided 20 g. P_2O_5 per day) was not high enough to maintain blood inorganic phosphorus levels, which had fallen considerably in both experiments by the time that the animals had been on the experimental diet for 2 to 3 months. The P supplement given to groups III and IV rapidly increased blood levels to, and maintained them at, the upper end of the normal range. It is interesting to note that under the conditions of these experiments the low phosphorus intake appeared to have no adverse effect on fertility.

The depressing effect of the high phosphorus intake on serum calcium levels even in the group receiving supplementary Ca was unexpected and at present no explanation can be offered. It is of interest that, particularly in 1958, some animals in the 2 groups having a high P intake showed serum Ca values below the normal range.

The depressing effect of a high Ca: P ratio on growth rate in both adult and young heifers (Group II, 1958 and 1959) provided confirmation of observations made by other workers (Swenson *et al.*, 1956). Although clearly a high Ca: P ratio did not affect the conception rate (Table I) it may not be unrelated to the fact that the only heifers failing to come into oestrus in 1959 (except for the sick animal) were both in the high Ca group and were therefore growing less well than the corresponding animals in the other 4 groups.

These observations suggest some of the complications that may arise if large supplements of calcium or phosphorus are given at random.

The slightly greater incidence of silent heats in the group on the Weybridge diet than in any of the other groups is a little unexpected, as the animals in this group may be assumed from their greater increase in weight during the course of the experiment (Table III), to have been in a more thriving condition throughout. Although the 3 heifers concerned were originally amongst the 4 smallest of their group, they were considerably larger by the time that service had started than the smallest animals in the other 4 groups.

Conclusion

The results of these 2 experiments clearly show that under the conditions described, a gross imbalance in the Ca: P ratio of the diet was entirely without effect on the conception rate, whether the general level of fertility in the herd was high or low.

Acknowledgments

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THE DAVID BLACK AWARD

The first winner of the David Black Award, presented by *Pig Farming*, is Sir John Hammond, C.B.E., F.R.S. This was the unanimous decision of the selection committee representing all sides of the pig industry.

The David Black Award is presented annually, to the person who is judged each year to have made the greatest contribution to the British pig industry. It takes the form of a solid silver casket, suitably engraved.

The committee selected Sir John Hammond as the 1960 winner "for his valuable and far-reaching research work in many branches of pig husbandry over a very long period." His study of pig problems whilst at Cambridge University produced many important results that have greatly benefited pig production in this country.

Sir John will receive the Award from the Minister of Agriculture, at a special luncheon in London next month.

(2) Some Aspects of Hypocalcaemia in Cattle

BY

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SUMMARY.—The literature relating to the exchange of calcium between the blood and tissues of lactating cattle is briefly reviewed and the importance of an uninterrupted absorption of calcium from the alimentary canal is stressed. The mode of action of various methods of preventing milk fever is considered.

SINCE 1925, when Little and Wright published their first results showing milk fever in cattle to be associated with a hypocalcaemia, the 2 conditions have tended to be regarded as synonymous. There have, however, been reports from time to time concerning the possible involvement of other substances particularly as an explanation for variations in symptoms (Barker, 1939; Marr, Moodie & Robertson, 1955) or as an attempt to explain failure to respond to repeated calcium therapy (Robertson, 1949; Hallgren, 1955). Nevertheless, while it is undoubtedly true that a hypocalcaemia can exist in cattle without any manifestation of the milk fever complex (Hallgren, 1959; Robertson, Paver, Barden & Marr, 1960) it seems certain that virtually all cases of true milk fever are associated with a considerable degree of hypocalcaemia at some stage.

The state of the calcium in the blood has been the subject of sporadic study. According to Irving (1957), the blood cells of the ox contain variable amounts of calcium, but the bulk of blood calcium is carried in the serum. The normal level lies between 8 and 12 mg. per 100 ml. serum and exists principally in 2 forms—a diffusible ionised form which accounts for 3.6 to 7.7 mg. per 100 ml. (Hallgren, 1959) and a non-diffusible protein bound portion. The combination of calcium with serum protein can be split readily when the serum calcium is removed by dialysis or

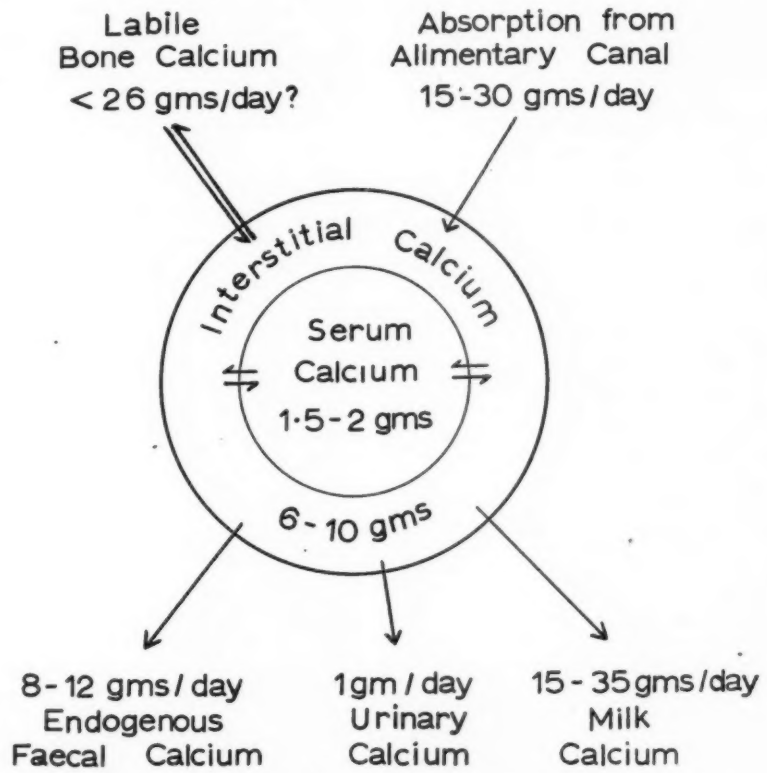

FIG. 1.—The exchange of calcium between serum and tissues in lactating cows.

oxalate precipitation. Similarly, milk fever is associated with reduction in both calcium ion concentration and bound calcium in the body fluids, but in some cases of hypocalcaemia the ionic concentration remains high although the bound calcium may fall (Hallgren, 1959). The same worker was unable to demonstrate any decrease in the serum protein of cows with hypocalcaemia, even where the bound calcium fraction was lowered without any concurrent change in ionic calcium. Larson and Kendall (1957), however, have recorded a lowering of serum protein at calving compared with 4 weeks precalving, while Vigue (1952) gives a total serum protein value of 5.8 gm. per 100 ml., which seems to be rather low, for over 50 cases of milk fever.

Calcium is transported by the blood and is constantly being exchanged. The total circulating calcium is of the order of 1.5 to 2 g. (based on a plasma volume of 4.5 per cent. of bodyweight (Dale, Burge & Brody, 1957)) and, as will be seen later, the daily turnover of calcium within the body can vary from about 10 g. in the non-productive cow to over 35 g. in the lactating cow. Thus, a quantity of calcium equal to the total amount in circulation may be removed every 1 to 5 hours depending on the physiological state of the animal.

The blood can draw on a number of sources to maintain its calcium level (Fig 1). The serum calcium is in equilibrium with the interstitial fluids and exchange between these 2 pools is considered to be very rapid, taking a few minutes at most. The total extracellular (interstitial + serum) calcium is probably of the order of 9 to 12 g. but no precise figures are available. In one dry Ayrshire cow carrying her second calf which died as a result of an intravenous injection of 19 g. sodium oxalate given as a 2 per cent. solution evenly over a period of 55 minutes, the serum calcium fell from 10.2 mg. per cent. to 3.0 mg. per cent. at the time of death. The sodium oxalate would account for 5.6 g. of calcium, presumably drawn from the extracellular calcium pool, which would indicate that the total pool in this animal was of the order of 8 g. Conversely, the intravenous injection of 4 ounces of calcium borogluconate solution containing approximately 8.4 g. calcium raised the serum calcium of 12 cows by 7.78 mg. per cent. 15 minutes after the injection (Moodie, Marr & Robertson, unpublished data). Luick. Boda and Kleiber (1957b) claim that a proportion of the bone calcium can also mix rapidly with the interstitial calcium, and estimate the extracellular plus this exchangeable bone calcium to total about 120 g. Such a high value, however, cannot be expected in all animals, since a reserve of this size and availability would prevent the development of clinical hypocalcaemia.

Bone calcium is said to exist in 2 forms—a labile component, which Luick *et al.* (1957b) estimate to be of the order of 2,000 to 4,000 g. (or 37 to 60 per cent. of the total bone calcium) in 4 sterile Jersey heifers, and a stable fraction which is not available to the circulation. The labile fraction is released from the bones by a complex mechanism, which is at present not understood, but is thought to involve parathyroid hormone. These workers calculated that the labile bone yields about 26 g. calcium per day, but whether this is true for older cows after a succession of heavy lactations has yet to be established. Hansard, Comar and Davis (1954), however, consider that the labile bone calcium in Herefords decreases from between 6 and 20 per cent. of the total bone calcium in 3-year-old cattle to between 2 and 5 per cent. in cattle 13 years of age. Under conditions of positive calcium balance, bone is withdrawing calcium from the circulation, but this is not an important consideration in heavily lactating cows.

Absorption of calcium from the alimentary canal varies according to age. Thus Hansard, Comar and Plumlee (1954) in their experiments with Hereford cattle came to the conclusion that the true digestibility of calcium decreases from 34 $\pm$ 8 per cent. in mature animals to 22 $\pm$ 4 per cent. in aged cattle. Working with dairy cattle, Conrad, Hansard and Hibbs (1956) estimated lactating cows to have a true calcium digestibility of 44 per cent. compared with a value of 33 per cent. for 3 aged dry dairy cows and 2 steers. The improvement in calcium digestibility in lactating cattle may not be due to physiological factors since in this experiment the dry and milking cows were fed markedly different types of rations with possibly quite different availabilities of calcium. Since, however, a dairy cow's ration often contains at least 40 to 65 g. calcium per day, it probably has available to it about 15 to 30 g. of dietary calcium daily, depending on age, appetite and type of feed.

Re-excretion of calcium through the gut is an important factor especially in older animals. In normal adult cows this amounts to about 8 to 12 g. per day and the value tends to remain constant as the animal ages (Hansard *et al.*, 1954; Conrad *et al.*, 1956). Thus, in older animals where calcium absorption is failing, the constancy of the endogenous faecal calcium can lead to negative balances even in the non-productive cow. Loss of calcium through the urine accounts for up to 1 g. per day and urinary calcium output appears to decrease at parturition (Ward, Blosser & Adams, 1953).

The calcium content of the milk is about 0.15 per cent. which means that every gallon produced removes about 7 g. of calcium. Colostrum contains about the same amount of calcium except during the first 24 hours when the concentration may be higher. Thus, a cow secreting 3 gallons of milk or colostrum per day loses 21 g. of calcium through the udder in addition to some 10 g. endogenous faecal calcium and up to 1 g. of urinary calcium daily. If this loss from the circulation is not met in full by absorption from the digestive system, the balance of the animal's requirements will have to be obtained from the bone. In the absence of replenishment of the blood from either the gut or the bone, or both, 1 gallon of colostrum would readily deplete the extracellular calcium pool to paretic levels.

The normal cow in milk is well able to maintain her serum calcium level, regardless of her age or state of nutrition, and there is some evidence that milk yield may be in some way balanced with calcium

intake (Espe & Smith, 1952). Therefore, the majority of cases of hypocalcaemia in the bovine animal cannot be explained unless a further factor is involved, such as a marked change in the calcium balance for which the animal cannot immediately compensate. Such a change could be the sudden increase in calcium output in the milk, or interruption to absorption of calcium from the gut (Marr, 1958), failure to mobilise calcium from the bones, or any combination of these in lactating animals. Urinary output and endogenous faecal loss do not appear to vary significantly and are unlikely to be of importance.

Milk fever is most common in the newly calved cow, usually occurring in older animals and in high producing strains of cows where the output of milk is usually greater and where, as we have seen, the availability of bone and alimentary calcium may be lower. It is believed that the dry cow is usually in positive calcium balance, while lactating cows during the first months of lactation are in negative balance (Espe *et al.*, 1952). The change from positive to negative balance occurs over a period of a very few days at calving; at the same time the secretion of milk is rising rapidly. Since, however, the loss of calcium in the colostrum of cows developing milk fever is no greater than in normally calving old cows (Hibbs, Pounden & Krauss, 1951), these factors by themselves do not account for the development of hypocalcaemia, especially when the loss of calcium into the udder in a number of cases would not appear to exceed a few grammes at the time milk fever develops (for example, in cases which occur before calving). Consideration of these matters leads to the conclusion that the hypocalcaemia in the calving cow is essentially a failure to obtain sufficient calcium from the gut or bone. If we refer to the figures given earlier in this paper it will be seen that a cow secreting colostrum at 3 to 4 gallons per day could not provide for both milk and endogenous faecal calcium from either the skeleton or the digestive system alone. An interruption in supply of even a few hours' duration from one of the sources could have serious repercussions.

Much has been written about the mobilisation of calcium from bone, but comparatively little is known about it in the ruminant. Even the action of parathyroid hormone is not clear and there would seem to be little evidence regarding the time required for adjustments in the rate of mobilisation to be completed.

Constipation is a well-known feature of milk fever and is generally assumed to be the result of the hypocalcaemia, since the injection of calcium is frequently followed by evacuation of the bowel. However, this does not exclude the possibility that stasis of gut movement at the time of calving impairs absorption of calcium and leads to a hypocalcaemia which, if it is sufficiently severe, may in turn lead to further stasis of the digestive system. Evidence of interference with alimentary activity is to be found in the paper by Ward *et al.* (1953) where feed and calcium intake remained normal over the calving period in heifers, but declined in older cows and in those which

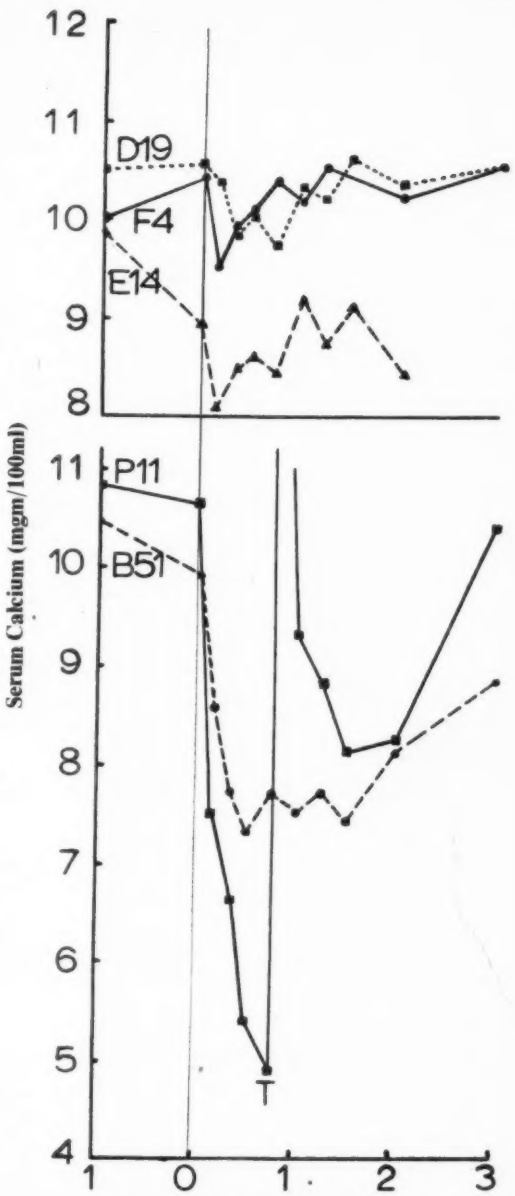

FIG. 2.—The effect of hyoscine hydrobromide injections on the serum calcium of five cows.

F4 Barren heifer 3 years old.

D19 Dry cow 5 years old carrying third calf.

E14 Cow 8 days after second calving. Four years old. Milk yield 33 lb.

B51 Cow 4½ months after fifth calving. Seven years old. Milk yield 32 lb.

P11 Cow 3½ months after eighth calving. Eleven years old. Milk yield 47½ lb.

T Treated with 350 ml. 25 per cent. calcium borogluconate intravenously.

developed milk fever. Similar results have been obtained in our own experiments with young and old cows (Moodie & Robertson, unpublished data). Faecal output was also depressed. Studies made by the author show that in some cows, including heifers, there may be a marked reduction in rumen activity for up to 24 hours before and just after calving. It should be noted that the decrease in appetite and in ruminal and bowel activity, where it occurs, precedes the fall of blood calcium in the normal calving cow.

The dependence of the lactating bovine animal on continuous absorption of calcium from the gut can be seen in Fig. 2 where 5 cows were treated by hyoscine hydrobromide injected subcutaneously. Full details are in the course of preparation for publication, but it will be seen that 2 dry cows showed no evidence of hypocalcaemia, in a young cow there was only a slight depression of blood calcium, but in 2 old cows on their fifth and eighth lactations respectively, there was a pronounced hypocalcaemia with the development of a milk-fever-like syndrome in the oldest cow. This occurred after 16 hours of continuous bowel stasis. The development of hypocalcaemia in this manner is in keeping with field observations reported by Marr (1958) and the experiments demonstrate the older cow's reliance on dietary calcium even over periods of less than a day. Similarly, Robertson *et al.* (1960) have induced hypocalcaemia in lactating cows after 3 to 5 days' starvation; the delay is probably due to a certain amount of alimentary absorption of calcium.

It would appear that a loss of calcium through the milk secretion is a necessary prerequisite for the lowering of blood calcium levels, as evidenced by the difficulty in inducing hypocalcaemia by starvation or stasis of the bowel and the rarity of authentic natural cases of hypocalcaemia in non-lactating animals. The essential cause of the condition must, however, be attributed to a deficiency of available calcium in the bones or an inability to mobilise calcium from the bones, to impairment of absorption of calcium from the digestive tract or to a combination of these factors. Information on the bone reserves of animals of different ages and on the rate of mobilisation of bone calcium is very scanty, but the dependence of the lactating animal on continuous activity of the alimentary canal has been demonstrated.

Prevention

Partial milking for the first few days after calving, and the prophylactic injection of calcium salts have been recommended for the prevention of milk fever. The idea behind partial milking was that it might reduce the drainage of calcium from the blood by causing a certain amount of back-pressure in the udder, but this will clearly not prevent the occurrence of hypocalcaemia before calving, at periods other than about calving or in those cases which never develop tension in the udder. Indeed, the indications are that neither partial milking (Neidermeier & Smith, 1948: Smith, Neidermeier & Hansen, 1948) nor prepartum milking (Smith & Blosser, 1947) affect the incidence of the disease.

Greig (1930) first suggested the use of injected calcium for the prevention of parturient hypocalcaemia, 2 injections with an interval of 24 hours being recommended. This procedure was based on the assumption that the curative action of calcium in clinical cases is simply a replacement mechanism. This, however, may not be the whole story since recovery can frequently be brought about by a few ounces of calcium borogluconate, which introduces only a few grammes of calcium into a system which has a turnover of 25 to 40 g. of calcium per day. Therefore, it would seem reasonable to suggest that calcium may exert some of its effect by assisting the return of alimentary activity to normal. Ward and Vair (1959) have attempted to prevent milk fever by feeding a calcium lactate—aluminium hydroxide compound to cows before calving, but it would appear doubtful if any real benefit was obtained.

The use of vitamin D as a preventive was first tried by Greig (1930) but it was not until 1955 that Hibbs and Pounden demonstrated the possibilities of the method. More recently Weighton (1958) has published results on 8 cows in this country. For the method to be effective, the vitamin D must be fed at high dosage level for only a few days before calving. Thirty million units per day for at least 3 days and not more than 7 days is suggested; feeding should be stopped then, otherwise there is a risk of toxicity developing. Studies by Conrad *et al.* (1956) using radioactive calcium have shown that the action of vitamin D is to stimulate the absorption of calcium from the alimentary canal. True digestibility rose from 33 per cent. and 44 per cent. in non-lactating and lactating cattle respectively, to 50 per cent. in both groups and this effect persisted for a few days after the withdrawal of the vitamin D supplement. The extra calcium absorbed did not appear to be re-excreted but was stored in the tissues of the body; in calves it may be held in the bones, but in adult cattle the deposition of calcium in the soft tissues of the body cannot be excluded (Swan, 1952). This reserve of calcium, which may amount to 20 to 40 g. during the course of a week could presumably be mobilised with considerable rapidity.

Boda and Cole (1954) and Boda (1956) have attempted to control milk fever by adjusting the Ca : P ratio of the diet. They found that rations containing 1 part of calcium to every 3–10 parts of phosphate fed to cows for several weeks before calving reduced the incidence of the disease. Normal rations were resumed as soon as the cows calved. Conversely Ender, Dishington and Helgebostad (1956) claim that a high Ca : P ratio before calving tends to increase the incidence of milk fever. Boda and Cole suggest that where an animal is operating under an adverse dietary calcium balance, the parathyroid glands are stimulated and calcium is mobilised from the bone to compensate for the dietary deficiency. After calving, when the diet is returned to a normal calcium to phosphorus ratio of 1 : 1, the animal can obtain dietary calcium much more readily than before and at the same time the parathyroids are still in a state of hyperactivity, thus protecting the animal over

(3) Calcium-Iron Relationships in Fattening Pigs

BY

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SUMMARY.—(1) *Calcium carbonate fed in large amount to pregnant and lactating gilts had no effect on their blood haemoglobin concentrations, nor did it affect either the blood haemoglobin concentrations or the initial growth rates of their offspring.*

(2) *Supplements of calcium carbonate fed to fattening pigs from weaning onwards can cause iron deficiency, shown by reductions in blood haemoglobin concentrations and rates of live-weight gain.*

(3) *This effect is especially marked in litters with low weaning weights, probably because their reserves of iron are generally lower.*

(4) *Iron injected at weaning will overcome these deleterious effects.*

(5) *Even if calcium carbonate is not fed, injections of iron at weaning may prove beneficial.*

IT has been shown (Richards & Greig, 1952; Greig, 1952) that when pregnant mice are fed a basal diet consisting largely of whole wheat and dried milk, with a rather low iron content, they succeed in rearing their litters fairly well and neither the young mice nor their mothers become grossly anaemic. However, when a 2 per cent. supplement of calcium carbonate is added to the diet both dams and offspring become anaemic, and the young mice either die or fail to grow well. Adding small amounts of an iron salt to the diet neutralises the effects of the calcium

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Some Aspects of Hypocalcaemia in Cattle.—*Concluded*

the first few critical days after calving. Subsequently Luick, Boda and Kleiber (1957a) have not been able to show by radioactive calcium studies that there is any difference in the transfer rate of calcium from the bone in cows on diets with Ca : P ratios varying from 6 : 1 to 1 : 7. The same authors (1957b) have, however, confirmed that the absorption of calcium from the alimentary canal is greater where a high calcium diet is fed.

A major disadvantage with this method of prevention is the tendency for the diet to be unpalatable, and there is difficulty in producing a ration with a Ca : P ratio of 1 : 7 and still maintaining the animal's energy and protein requirements. Boda (1956) claims that there is no adverse effect on parturition, milk yield or the health of the calf, but the possibility of repercussions in later years due to throwing animals purposely into a negative calcium balance for periods of several weeks before calving cannot be ignored.

It would seem that at the present there is no ideal method of preventing hypocalcaemia. Augmenting the animal's intake by calcium injection or dietary calcium before calving does not seem to have received widespread acceptance, while the methods of Boda and Cole, and Hibbs *et al.* both possess disadvantages. This latter method, however, is potentially useful in the absence of a more convenient dietary or managemental regime which will ensure the building up or maintenance of a readily available calcium reserve especially in aged cattle.

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carbonate, and when the basal diet is rich in iron calcium carbonate is almost without effect unless the level of supplementation be greatly increased (Greig, 1955). Further work, to be published shortly, has indicated that calcium carbonate diminishes the availability of iron in the stomach and duodenum owing to its antacid properties.

In view of the importance of iron to the piglet, observations were extended to this species in order to discover whether the same principles applied to it. The present paper summarises some of this work.

Breeding Pigs

Seven pairs of littermate guts which had been reared out of doors were fed on ordinary sow and weaner meal throughout pregnancy and lactation, but one member of each pair was given a 6 per cent. supplement of calcium carbonate. This high and—from the practical point of view—unrealistic level was chosen because the iron content of the sow and weaner meal was also high.

The supplement proved harmful to the general health of the pigs, in that all lost weight and digestive disorders were common, but breeding efficiency was unaffected and blood studies revealed no evidence of anaemia at any time.

Two litters were bred from each pig. For the first 4 weeks of their lives the litters were denied access to iron other than the small amounts obtained by nibbling at their mothers' food. Each piglet was weighed and bled for haematological studies weekly. During the whole of this period no important differences developed between the 2 groups of piglets. The mean blood haemoglobin concentration (Hb) fell sharply in both groups, as was to be expected in piglets maintained without iron, but the pattern was similar in each case. Growth-rate too was poor, but again almost equally poor in both groups. At 4 weeks of age all the piglets were given iron medication by mouth, and thereafter made much better progress. At 8 weeks of age—by which time, of course, the young pigs were eating quite large amounts of meal—the Hb levels had been largely restored, but the pigs in the supplemented group now weighed on average about 9 lb. less than those in the control group; this difference was not statistically significant, but the number of experimental animals was relatively small.

The experiment therefore showed that even a large dietary supplement of calcium carbonate had no effect on the Hb concentrations of breeding pigs, nor did it affect either the Hb concentrations or initial growth rates of their offspring. This must mean that either calcium carbonate does not affect iron absorption in pigs at it does in mice, or if it does the animals' iron reserves may be sufficient to meet their breeding requirements. As the gilts in question had been reared out of doors, the presumption must be that their iron stores were full.

On the other hand, it does not necessarily follow that calcium carbonate might not induce iron deficiency in animals such as young fattening pigs whose iron reserves are not yet fully built up; indeed, if the difference in growth performance mentioned above were a real and valid one, it would be consistent with such a suggestion.

Fattening Pigs

A series of experiments was therefore carried out to examine the effects of diets containing calcium carbonate when fed to young fattening pigs.

In the first of these, 16 female pigs from 2 litters were, as far as was possible, denied access to adventitious sources of iron from birth until weaned at 8 weeks of age. The concrete-floored pens in which they were born and reared were cleaned frequently, and all fixtures and fittings were either non-ferrous or had been liberally coated with paint. However, in order to prevent the development of severe signs of piglet anaemia, each pig was given an exactly equal quantity of iron dextran by intramuscular injection at 4 days old. At weaning, 4 pigs from each litter were chosen by a method of random selection to form a control group, the remaining 2 half-litters forming the supplemented group. Because of the litter factor there were thus in effect 4 litter/diet groups of 4 pigs each. The controls were fed a basal diet based on wheat and milk, while the supplemented group received the same diet but with a 2 per cent. supplement of calcium carbonate added. All pigs were weighed and subjected to blood sampling at intervals.

A summary of the results at 4 and 8 weeks is given in Table I. At the fourth week after weaning

TABLE I
MEAN HAEMOGLOBIN CONCENTRATIONS (HB) AND LIVE-WEIGHTS OF PIGS FED DIETS WITH OR WITHOUT A 2 PER CENT. SUPPLEMENT OF CALCIUM CARBONATE

	Initial	4 weeks	8 weeks
Hb (g. per 100 ml.)			
Control group :			
Litter A	3·8	8·0	10·8
Litter B	5·5	8·4	11·6
Overall mean	4·6	8·2	11·2
Supplemented group:			
Litter A	4·7	6·5	8·1
Litter B	5·7	9·5	10·8
Overall mean	5·2	8·0	9·4
Live-weight (lbs.)			
Control group :			
Litter A	26·0	47·8	86·0
Litter B	33·8	57·8	95·5
Overall mean	29·9	52·8	90·8
Supplemented group:			
Litter A	29·5	47·2	73·5
Litter B	37·5	64·5	101·2
Overall mean	33·0	55·9	87·4
Adjusted live-weight (lbs.)			
Control group :			
Litter A	32·0	59·0	100·4
Litter B	32·0	54·5	91·3
Overall mean	32·0	56·8	95·9
Supplemented group:			
Litter A	32·0	51·8	79·5
Litter B	32·0	54·3	88·0
Overall mean	32·0	53·1	83·8

overall differences between the control and supplemented groups were small, but after 8 weeks the depression in the overall mean Hb concentration of the pigs receiving calcium carbonate was highly significant ($P<0.01$). On the other hand, overall mean weights were not significantly different.

However, if the effects of the litter factor are now considered, it can be seen that throughout the experiment, in both supplemented and control groups, Hb values were always higher with one litter than with the other ($P<0.01$ for Hb; $P<0.05$ for weight). This might have been attributable to some inherited characteristic, but equally it might have resulted from differences in the levels of iron reserves.

Study of the initial weights and initial Hb concentrations of individual pigs threw some light on this point, as a very highly significant correlation could be shown to exist between initial weight and the weights at both 4 and 8 weeks ($P<0.001$). By means of the regression coefficients the weights at 4 and 8 weeks were adjusted with reference to an initial weight of 32 lb., the approximate overall mean.

The adjusted figures are also shown in Table I. The overall difference in weight at 8 weeks between the control and supplemented groups was now more obvious and indeed was statistically significant ($P<0.05$). Further, overall litter differences were no longer significant, suggesting that inherited differences in growth potential may not have been very important; but the effect of the calcium carbonate supplement was still much greater with one litter than with the other, a result that would be consistent with the view that the original state of the iron reserves was the factor of major importance.

In the next experiment an attempt was made to study the influences of this and other factors more fully. Twenty pigs from 2 litters were fed a more normal basal diet (sow and weaner meal) from weaning onwards. Ten of them were fed basal diet alone and the remaining 10 received the same diet with a 5 per cent. supplement of calcium carbonate. Pigs from the 2 litters were equally divided between each group, and, moreover, each group of 10 pigs consisted of 5 males (castrated at 6 weeks old) and 5 females; 5 pigs with a high initial Hb (over 8 g. per 100 ml.) and 5 with a low initial Hb; and 5 pigs with a heavy initial (weaning) weight (over 40 lb.) and 5 with a lighter initial weight. Within this stratification, distribution between the groups was random. This experimental design permitted separation and evaluation of each of the factors (1) supplement, (2) litter, (3) sex, (4) initial Hb and (5) initial weight.

All pigs were weighed and subjected to blood sampling at weaning and at weekly intervals thereafter for 8 weeks. Table II summarises the readings obtained on 3 of these occasions, grouped in various ways.

It will be seen that, overall, the calcium carbonate supplement reduced mean Hb at both 4 and 8 weeks ($P<0.05$), but on the other hand the overall mean difference in live-weight was not significant. Nor was there any obvious difference in the mode of response of the two litters, although weight gains in both groups were greater with one litter than with the other. Males and females also responded to the supplement in the same way, but it was interesting to note that in both groups the males grew faster than the females. Initial Hb did not appear to influence the later Hb readings, but the depressing effect of calcium carbonate on rate of live-weight gain seemed to be rather more marked in pigs with a low initial Hb. The most influential factor, however, was initial weight, which, as before, was found to be closely correlated with the weight at both 4 weeks and 8 weeks (P 0.001), and it was plain that the pigs most affected by calcium carbonate were those with a low initial live-weight.

TABLE II

MEAN HAEMOGLOBIN CONCENTRATION (HB) AND LIVE-WEIGHTS OF FATTENING PIGS FED DIETS WITH OR WITHOUT A 5 PER CENT. SUPPLEMENT OF CALCIUM CARBONATE, GROUPED TO ISOLATE THE INFLUENCES OF 5 FACTORS

Factor		Supplement	Hb (g per 100 ml.)			Live-weight (lb.)		
			Initial	4 weeks	8 weeks	Initial	4 weeks	8 weeks
1. Supplement	Overall	Control	8·5	10·5	9·1	42·7	56·6	86·5
		5% $CaCO_3$	8·7	8·0	8·0	43·7	53·9	80·7
2. Litter	A	Control	7·6	10·3	9·0	40·8	49·3	73·2
		5% $CaCO_3$	7·9	8·2	8·7	44·8	51·3	73·9
	B	Control	9·1	10·7	9·1	44·0	61·5	95·3
		5% $CaCO_3$	9·2	7·9	7·8	43·0	55·7	85·2
3. Sex	Males	Control	9·3	10·6	9·1	43·8	56·1	92·6
		5% $CaCO_3$	9·0	8·3	7·8	47·0	61·2	90·3
	Females	Control	7·7	10·4	9·0	41·6	57·1	80·3
		5% $CaCO_3$	8·4	7·8	8·2	40·4	46·6	71·0
4. Initial Hb	High	Control	9·9	10·5	9·0	49·0	65·2	96·6
		5% $CaCO_3$	10·3	8·2	8·0	45·0	57·2	85·1
	Low	Control	7·2	10·5	9·1	36·4	48·0	76·3
		5% $CaCO_3$	7·1	7·8	8·1	42·4	50·6	76·2
5. Initial weight	Heavy	Control	9·7	10·7	9·0	51·8	66·3	96·0
		5% $CaCO_3$	9·1	8·6	8·5	51·2	65·8	98·9
	Light	Control	7·3	10·4	9·1	33·6	46·9	76·8
		5 $CaCO_3$	8·3	7·5	7·6	36·2	42·0	62·4

This was conclusively proved by showing that the regressions for weight at 8 weeks on initial weight were different for the control and supplemented groups ($P<0.05$). When the regression coefficients were applied to initial weights of 35, 40, 45, 50 and 55 lb. respectively, the differences in final weight between the 2 groups were large and significant in the first 2 cases ($P<0.01$ and $P<0.05$ respectively) but grew progressively smaller and were not significant in the remaining 3.

It seemed likely that if the harmful effects of calcium carbonate are mediated through an induced deficiency of iron, the special susceptibility to it of pigs with a low weaning weight could be accounted for by impoverished stores of iron, insufficient in amount to meet the animals' requirements under conditions of minimal iron absorption. This view was supported by the finding of a significant correlation between initial weight and initial Hb ($P<0.05$), indicating that in general the lightest pigs also had the lowest Hb values.

Nevertheless, calcium carbonate might also have had some other more direct effect. To decide this point, 20 weaning pigs were divided into 4 groups of 5. All were fed good quality meal, but 2 groups received a 4 per cent. supplement of calcium carbonate. The pigs in one of these groups and also those in one of the unsupplemented groups were each given iron dextran (250 mg. Fe) intramuscularly at weaning and again 4 weeks later. Results are shown in Table III (*a*). At the end of the 8th week the pigs receiving calcium carbonate but no iron were distinctly lighter than those in other groups; the iron injections appeared to have exerted a protective influence, however, for the iron-injected pigs, even though receiving calcium carbonate, were as heavy as the controls. This result shows that since the depressing effect of calcium carbonate on rate of live-weight gain can be overcome by providing sufficient iron, it must be mediated, at least in the main, through a conditioned iron deficiency.

It could be said with justice that the levels of calcium carbonate used in the above experiments were unrealistically high. They were chosen, of course, in order to establish the fact of the deleterious effect of such supplements to fattening pigs rather than to investigate the practical hazards likely to result from the feeding of more moderate amounts. With this object achieved, however, further trials were conducted to determine whether smaller amounts of calcium carbonate in ordinary fattening meal would result in poorer live-weight gains. The results of one such trial are given in Table III (*b*), which shows that the supplemented pigs had made poor live-weight gains after 8 weeks, though not after 4 weeks. To explain this difference, it may be surmised that after only 4 weeks the animals' reserves of iron had not yet become exhausted.

The results of these experiments emphasise the importance of sufficient iron for the rapid growth of fattening pigs, and raise the question of whether this metal is ever a limiting factor at this stage of a pig's life even if the diet does not contain a calcium carbonate supplement. In Table IV are shown the results of 2 small-scale trials in which a single injection of iron dextran was given at weaning to apparently healthy pigs on ordinary diets. In the first of these (Table IV (*a*)) a dose of 100 mg. Fe per pig was given to half of the animals, and these subsequently made better live-weight gains than their fellows. The fact that the difference between the groups tended to contract rather than widen between the 4th and 8th week may have been due to inadequate

(*Concluded at the foot of p.* 1153)

TABLE III
WEIGHTS OF FATTENING PIGS

Supplements	No. of pigs	Mean weaning weight (lb.)	Mean weight (lb.)			
			Weeks after weaning	Control	$CaCO_3$	Fe	$CaCO_3$ + Fe
(*a*) 4 per cent. $CaCO_3$ in diet ; 250 mg. Fe intramuscularly at 0 and 4 weeks.	20	31·0	8	70·0	65·5	71·7	70·0
(*b*) 2 per cent. $CaCO_3$ in diet	20	28·5	4	44·5	43·9		
			8	80·0	75·0		

TABLE IV
WEIGHT GAINS OF FATTENING PIGS FOLLOWING SINGLE IRON INJECTIONS AT WEANING

Dose of Fe	No. of pigs	Mean weaning weight (lb.)	Mean gain in weight (lb.)		
			Weeks after weaning	Control	Injected
(*a*) 100 mg.	12	32·7	4	12·6	19·4
			8	34·1	39·3
(*b*) 250 mg.	10	35·4	4	30·2	33·0
	9	40·7	4	17·2	23·5
	12	41·8	4	20·5	21·6
	11	44·5	4	25·0	25·8

(4) Calcium and Phosphorus Imbalance in Growing Dogs

BY

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SUMMARY.—Puppies fed on diets deficient in calcium or phosphorus or both showed radiological and histological changes in the bones, and changes in the blood mineral levels. Different diets produced different effects, the calcium-deficient diet producing changes which were distinct from those produced by the phosphorus-deficient diet. These differences are described, as well as the effects of various treatments. A brief review of the literature is included.

IN 1933 Sir Arnold Theiler, Director of Veterinary Research in South Africa, said, "Diseases affecting the skeletons as a whole have been described in the veterinary literature under various names, and conceptions of their nature have varied widely. Even to-day the names in common use do not always reflect the real character of the disease, and the same name is sometimes used for pathologically diverse disorders."

In the intervening 27 years, much has been done to disperse this confusion, but there are still skeletal abnormalities, the aetiological factors of which remain in doubt. This is true of the dog. Some skeletal disorders of the dog have been satisfactorily solved. For instance, osteodystrophia fibrosa in the dog has clearly been shown to be due to hyperparathyroidism consequent upon renal impairment causing imperfect excretion of phosphate (Neilsen & McSherry, 1954).

On the other hand; there is an osteodystrophic condition which occurs not uncommonly in growing dogs and which, at present, is often called osteogenesis imperfecta because it resembles, to some extent, this condition in humans. It has, however, never been proven to be an hereditary condition and its true aetiology remains obscure.

Rickets is a word which has been used loosely to describe bone conditions, often on aetiological or clinical grounds. For the purposes of this investigation rickets is defined (Follis, 1948; Harris, 1956) as a condition which affects both the shaft and the cartilage-shaft junction of the bone. The changes are: 1. In the shaft; the deposition of osteoid which is not properly calcified. On histological examination abnormal amounts of uncalcified osteoid can be seen. Follis considers that rickets can be present even if no excess osteoid tissue is present in the shaft. 2. At the cartilage-shaft junction:

(a) Failure of lime salts to be deposited in the cartilagenous matrix material.

(b) Failure of cartilage cells to undergo degeneration, so that capillaries are unable to penetrate the cartilage except in very irregular fashion.

The result of these changes is a widening of the epiphyseal line and a very irregular cartilage-shaft junction.

Rickets occurs sporadically in puppies. Very many more suffer from a condition which, because clinically the bones are abnormal, is mistakenly diagnosed as rickets. Biochemically and radiographically, however, it seems to be a separate entity.

Dietetic factors mainly responsible for skeletal development are calcium, phosphorus, vitamin D and vitamin A. The effect of these factors has been

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Calcium-Iron Relationships in Fattening Pigs.—*Concluded*

dosage. In the second trial (Table IV (*b*)), a dose of 250 mg. Fe per pig was given to half of the pigs in each of 4 litters in a commercial herd. The herd was well managed, and the pigs were of good type, well fed and with good weaning weights, and each had been dosed with reduced iron on 3 occasions during the first 3 weeks of life. Hb values were high, and there was nothing to suggest that the pigs were likely to be iron-deficient. Four weeks later the treated groups were all heavier than the corresponding untreated ones, though differences were in most cases small. In one litter, however, the difference was large and (although the litter comprised only 9 pigs in all) statistically significant ($P<0.05$), representing an improvement of 36.6 per cent. In only one litter was it possible to follow the pigs up to 8 weeks after weaning, by which time the mean difference had widened from less than 3 lb. to over 5 lb. per pig. This increment may not seem spectacular, yet if it had been no more than maintained to bacon weight it would represent, at current prices, a difference of fully 10s. per pig.

It thus seems clear that if fattening pigs are to realise their full potential they must have a sufficiency of iron, and that the likelihood of failure in this regard is increased if the diet includes a supplement of calcium carbonate.

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studied by various workers, with very different results.

Morgan (1940) in California came to the conclusion that up to 250 I.U. of vitamin D per kg. bodyweight per day was required, particularly in large breeds, to prevent the occurrence of rickets even on a diet containing satisfactory amounts of calcium and phosphorus.

Marek and Wellman (1931) stated that the absolute amounts of calcium and phosphorus in the diets of puppies, and the ratio between them, were of great importance in the prevention of rickets. They showed that if these minerals were given in what they considered correct amounts and proportions rickets did not develop and the amount of vitamin D was relatively unimportant.

Both groups of workers agreed that vitamin D could not completely prevent bone changes if the minerals were not supplied in suitable amounts. Nevertheless, administration of vitamin D could reduce the severity of the condition.

Mellanby (1921) showed that certain fats could prevent rickets, but concluded that more calcium and phosphorus could not, on the evidence that one pup given a supplement of 5 g. calcium phosphate per day developed rickets.

In Sweden Sjoberg (1942) showed that animals on inadequate vitamin D did not develop rickets if sufficient calcium and phosphate were given, and that animals which had developed rickets recovered if the mineral deficiency was corrected.

The action of vitamin D had been studied by numerous workers (Harris, 1932, 1956; Crawford *et al.*, 1957; Hendricks *et al.*, 1947; Cramer *et al.*, 1957; Harrison & Harrison, 1958; Harris & Innes, 1931; Cohn & Greenberg, 1939; Freeman & Farmer, 1935; Pappenheimer, 1930; Jones, 1942; Neuman & Neuman, 1948). It has been shown to improve the absorption of calcium from the gut at normal dosage. If the dietary mineral is low or the vitamin D intake is excessive, bone absorption occurs (Harris, 1932; Harris & Innes, 1931). This resorption appeared to occur in the diaphysis as well as in the epiphysis (Crawford *et al.*, 1957). No one as yet knows exactly how vitamin D acts in the body, but there is some evidence that it is closely related to citrate metabolism (Lanford, 1939; Harrison & Harrison, 1958).

The dietary levels of calcium and phosphorus required for optimum skeletal growth in pups are given as 0.5 per cent. calcium and 0.4 per cent. phosphorus (Schwick, 1959). The minimum levels are probably about 0.35 per cent. for both calcium and phosphorus (Gaunt & Irving, 1941; Day & McCallum, 1939; Bell, Cuthbertson & Orr, 1942). The ratio of calcium : phosphorus is important especially if the level of one of them is near the minimum requirements; if both are supplied in adequate amounts, the ratio is probably not important unless there is an extreme excess of one mineral (Gaunt & Irving).

The action of phytin in cereal components of a diet must be borne in mind. Phytin contains phosphate, and since it is not completely broken down in the alimentary canal of the dog the available phosphorus in the diet will be less than the actual amount and this may produce bone changes due to an insufficient absorption of phosphorus. Similarly, phytic acid or phytate will combine with calcium in the diet and prevent absorption, precipitating bone changes if the calcium content of the diet is minimal (Harrison & Mellanby, 1939).

We have been carrying out some experimental work in Glasgow in an attempt to elucidate some of the osteodystrophies that occur in puppies.

Schnelle (1950) and Malherbe (1956) show radiographs of the limbs of dogs suffering from a condition which they diagnose as rickets. In none of them are the epiphyseal lines wider than normal. Schnelle advocates the use of vitamin D to cure the condition, while Malherbe quotes cases in which improvement of the diet and the administration of vitamin A caused healing of the lesions.

Ender *et al.* (1949) produced rickets in fox cubs and puppies on calcium-deficient and phosphorus-deficient diets. They claimed that both diets produced identical bone changes. Korenchevsky (1922) carried out similar experiments on rats, and produced on a low calcium diet " pseudo rachitic osteoporosis " in which rachitic changes occurred at the proliferating cartilage, but there was no marked osteoid, and osteoporosis of the shaft of the bones occurred. On a diet deficient in vitamin D and calcium true rickets was produced. Scott (1959) found that a low calcium diet produced osteoporosis, but no rickets in kittens.

In order to gain further knowledge of rickets, experimental puppies have been given a diet containing varying amounts of calcium and phosphorus and with varying Ca : P ratios. The effect of vitamin D administration has also been studied.

Experimental Methods

Twenty-one puppies aged 8 and 10 weeks were used in these experiments; their weights at the start of the experiments varied between 6 and 12 lb.

The basal diet consisted of: —

75 per cent. Flaked maize.
23 per cent. Fibrinogen meal.
1 per cent. Common salt.
1 per cent. Brewers' yeast.

To this basal diet were added varying amounts of calcium carbonate or acid sodium phosphate to produce varying absolute amounts of calcium and phosphorus in the diet and varying Ca : P ratios. The basal diet contained 0.02 per cent. calcium and 0.12 per cent. phosphorus with a Ca : P ratio of 1 : 6. The puppies were allowed exercise outside, but no vitamin D supplements were supplied except where this is specifically mentioned.

Analytical Methods

Plasma calcium values were estimated by the oxalate precipitation method of Kramer & Tisdall (1921). Plasma phosphate values were estimated by the method of Fiske and Subbarow (1925). Plasma alkaline phosphatase values were estimated by the method of King and Armstrong (1934) as modified by King *et al* (1937).

Bone ash values were calculated by the following method: The bones were cleaned and dried at 95°C, extracted with petroleum ether 40-60, dried in the oven at 95°C for 12 hours and weighed. They were then ashed at 500°C and weighed.

JAMES R. CAMPBELL.—CALCIUM AND PHOSPHORUS IMBALANCE IN GROWING DOGS

PLATE I.—Showing an osteodystrophic condition characterised by disruption of the bone at the junction of Metaphysis and Diaphysis but no rachitic enlargement of the Epiphyseal Plate.

Plate II.—Showing generalised loss of bone density; very thin, and in places lamellated, cortices; very marked mineral deposition at the area of provisional calcification. This latter finding is most evident in the forelimb. The hind leg shows a pathological fracture. There is no enlargement of the Epiphyseal Plate.

A

B

PLATE III.—A. This shows the radiographic appearance of the bones in a probable case of Infantile Scurvy. The features are (1) normal width of Epiphyseal Plate; (2) area of decreased density in the Metaphysis (scurvy line or gerustmark); (3) subperiosteal haemorrhage (seen calcified in III B)
B. Healed scurvy. The same animal one month later.

PLATE IV.—Appearance of limbs of a dog on a diet low in phosphorus. The Epiphyseal Plate is very wide, but there is little distortion of the Metaphysis and poor density at the zone of provisional calcification.

PLATE VI.—Showing histological features of the epiphyseal area of a long bone of a dog on a diet low in phosphorus. Stained by Masson. (× 10)
(E) Cartilaginous Epiphyseal Plate, thickened with extremely irregular edge.
(P) Primary Spongiosa, showing thick, irregular, uncalcified trabeculae.
(S) Spongiosa. Trabeculation of more normal size, architecture and mineralisation (dark area).

PLATE V.—Appearance of limbs of dog on a diet low in calcium. The Epiphyseal Plate is not so markedly widened as in Plate IV. The Metaphysis shows "mushrooming." Provisional calcification is evident. Some bowing of the leg can be seen.

PLATE VI

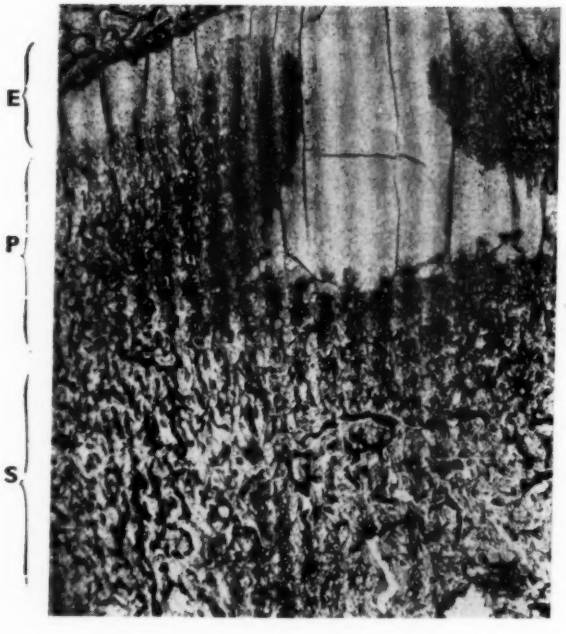

PLATE VII.—Histological features of the epiphyseal area of a long bone of a dog on a diet low in calcium. Stained by Masson. (× 10)
(E) Cartilaginous Epiphyseal Plate, showing areas of thickening and irregularity.
(P) Primary spongiosa. The trabeculae are extremely small and weak, but are fairly well calcified.
(S) Spongiosa. Small, distorted, disarranged but well calcified trabeculae.

Bone sections were decalcified in 10 per cent. formic acid.

Results

1. *Low Calcium diet*

Two diets low in calcium were used: the basal diet containing 0.02 per cent. Ca and with a Ca:P ratio of 1:6, and the basal diet with 3 g. 100 g. acid sodium phosphate added, giving a Ca:P ratio of approximately 1:40. There was no appreciable difference in the effects of these 2 diets. Eight puppies of 3 different litters received this type of diet and all developed radiological signs of rickets within 7 weeks. Pain was a marked feature in this group, and was evident before any changes appeared in the legs. Sometimes the animals refused even to stand up. The pain could not be localised in any particular site. Bowing of the legs occurred later and was invariably a lateral deviation of the radius. After 7 weeks on the diet the radiographs of the radius and ulna showed progressive widening of the epiphyseal plates, with, in this group, a line of calcification still present at the metaphyses.

Estimations carried out on the blood showed a marked fall in the plasma calcium level, a slight drop in the plasma phosphorus, and a very marked increase in the plasma alkaline phosphate (Table I). These changes occurred within 3 weeks of altering the diet.

TABLE I

PLASMA LEVELS OF CALCIUM PHOSPHORUS AND ALKALINE PHOSPHATASE IN PUPS

Type of diet	Ca mg. per 100 ml.	Phosphorus mg. per 100 ml.	Alkaline Phosphatase King-Armstrong Units
*Normal	11·9±1·7	7·8±1·0	17·5± 9·1
Calcium deficient	8·0±1·24†	6·5±1·2†	36 ±11·5†
Phosphorus deficient	11·8±1·5	2·4±0·8†	21 ± 9·6‡

* Normal levels are calculated from approximately 100 samples taken from privately owned pups.
† $p > 0.001$.
‡ $p > 0.05$.

Histological examination of sections of the epiphyseal area showed increased thickness of the proliferating cartilage, irregularity of the edge of the cartilage but no excess osteoid in the primary spongiosa. The trabeculae were, in fact, smaller and fewer than normal, but seemed to be normally mineralised.

The puppies on the low calcium diet grew fairly well, showing an average weight increase of 5 oz. per week.

2. *Low Phosphorus diet*

This diet consisted of the basal diet plus 3 g./100 g. of calcium carbonate, giving a Ca:P ratio of 10:1 and absolute amounts of calcium and phosphorus of approximately 1.2 g. and 0.12 g. respectively.

Eight puppies from 2 litters received this diet and showed radiographic signs of rickets within 4 weeks of altering the diet. Pain was not a feature of this group, and the animals finally showed plantigrade stance, with inward bowing of the limbs.

The radiographs of the limbs showed differences between this group and the low calcium group. The epiphyseal lines became very much wider in this group and there were no signs of bone growth and calcification at the metaphysis.

Biochemical estimations showed normal plasma calcium levels, but very low phosphorus levels, with a small but significant rise in alkaline phosphatase (Table I). These changes were evident within 3 weeks.

Histological examination showed marked overgrowth of the proliferating cartilage, irregular breakdown of the cartilage and the formation of large masses of non-mineralised, thickened, irregular osteoid trabeculae.

The puppies on this diet showed very poor growth, averaging less than 1 oz per week weight gain.

3. *Minimum diet*

To the basal diet was added sufficient $Ca\,Co_3$ and $Na\,H_2\,Po_4$ to bring the Ca and P levels in the diet to approximately 0.35 per cent. *i.e.* ratio 1:1.

Two puppies which already had rickets but which were showing healing of the lesions on a normal diet were given the above mixture. Healing stopped and progression of the rachitic lesions recurred.

During the 3 weeks the dogs were on normal diet the plasma mineral values rose to normal. On the experimental diet both calcium and phosphorus levels in the plasma fell below normal.

4. *Low Mineral diet*

In this experiment the basal diet was fortified with a $Ca\,Co_3$ sufficient to raise the calcium level to 0.12 per cent. giving a Ca:P ratio of 1:1.

The 3 puppies on this diet developed rickets. Radiographs resembled those of the animals on the low calcium diet. Biochemical estimations on the blood, however, showed normal calcium values (11.8 ± 0.95). The phosphorus values were slightly low (5.6 ± 1.8) and the alkaline phosphatase values were high (40.3 ± 11.1).

The ash content of the bones of all the animals in Groups 1 to 4 was lower than normal, indicating a condition of osteomalacia. Group 1 (low Ca) however, showed a more advanced osteoporotic condition than the animals in Group II (low phosphorus). This was calculated by dividing the weight of the dried fat-free humerus and femur of each animal by the total bodyweight, giving a figure representing the total mass of bone. This figure was significantly lower in the low calcium group than in the low phosphorus group. Due to the small number of animals employed these figures are not entirely conclusive but they indicate that osteoporosis is a marked feature of low calcium intake. The percentage ash content of the bones of the 2 groups were not significantly different. (See Table II.)

TABLE II

Diet	Number of animals	Bone weight / Bodyweight	Percentage ash content
Low calcium	8	0·287 ± 0·037	37·1 ± 5·1
Low Phosphorus	5	0·389 ± 0·081	33·8 ± 3·6

The effect of Vitamin D in the healing of Rickets

In this investigation animals which were already suffering from rickets, due to both calcium and phosphorus deficiency, were treated with (a) vitamin D; (b) rectification of mineral deficiency; (c) change to normal diet. The progress of healing, as diagnosed radiographically is illustrated in Table III.

TABLE III

Dog	Diet	Therapy	Days before 1st sign of healing	Days before marked healing
12·352/6	Low Phosphorus	Normal diet	24	36
12·352/1	Low Phosphorus	Phosphorus supplement	2	20
12·352/2	Low Phosphorus	Vitamin D	9	Still not marked after 60 days
13·086/5	Low Calcium	Vitamin D	34	60

The effect of Vitamin D on Plasma Mineral Values

Plasma mineral values of the animals changed to a balanced diet following phosphorus deficiency showed immediate marked changes. The level of plasma phosphorus rose, and later the plasma calcium level fell, then gradually rose again to normal. This is thought to indicate that as soon as blood mineral values reached near normal values, calcification of bone occurred causing a temporary drop in plasma calcium.

The administration of vitamin D (as D_2 or D_3) to those animals on phosphorus-deficient or calcium-O-deficient diets caused, if any, only small transient changes in the plasma mineral values.

The effect of Vitamin D on ash content of the Bones

The ash content of femur and humerus of each animal was measured. The results are given in Table IV.

TABLE IV

Dog	Diet	Treatment	Bone	Per cent. ash
13572/2	Low Calcium	—	Femur Humerus	34 33
12352/3	Low Phosphorus	—	Femur Humerus	38 39
13086/5	Low Calcium	Vitamin D	Femur Humerus	39 42
12352/2	Low Phosphorus	Vitamin D	Femur Humerus	42 43
12352/6	Low Phosphorus	Normal diet	Femur Humerus	44 46
12352/1	Low Phosphorus	Mineral supplement	Femur Humerus	46 47

Discussion

Rachitic changes were produced on diets deficient in either phosphorus or calcium. On a low calcium diet the lesions of rickets were combined with an osteoporotic condition. This double effect may explain the original confusion over pseudo-rachitic osteoporosis (Korenchevsky). No frank tetany was observed in any of the pups but some of those on low calcium diet seemed more nervous than normal. No osteodystrophia fibrosa was seen in the calcium-deficient pups (Morgan, 1934).

The fact that the diet containing 0.35 per cent. Ca and P could not maintain healing in rachitic pups is not conclusive, since maize contains a lot of phytin and practically no phytase (Spitzer & Phillips, 1945). The available calcium and phosphorus in the diet would probably be lower than the apparent values.

Conclusions

1. Rickets has been produced, in the circumstances described, on diets which are:
   (a) Low in calcium
   (b) Low in phosphorus
   (c) Low in both.

2. The lesions produced by a low calcium diet differed from those produced by a low phosphorus diet in that they were to some extent altered by a concomitant osteoporosis.

3. The 2 conditions are radiologically, biochemically, and histologically distinct.

4. Vitamin D in these circumstances does not appear to be as effective as a balanced mineral diet in promoting healing of rickets.

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THE SPEAKERS' INTRODUCTION

The Chairman, Professor W. L. Weipers, introduced the first speaker.

Miss A. Littlejohn, presenting the paper by Miss G. Lewis and herself, explained that she was presenting it as a representative of a team. The paper was not the work of any one person.

The task of explaining the general outline of the experiment was easy. It had been suggested that some, at least, of the non-specific infertility in dairy cattle might be caused by an imbalance in the ratio of calcium to phosphorus in the diet. This theory had first been put forward by a New Zealand worker and had since been developed by Mr. Hignett at Frant. Mr. Hignett's conclusions were based on the results obtained from a number of heifers entering the Frant herd over a period of several successive years. He had then combined the results relating to fertility and compared them with the diet that the animals were receiving.

In the experiments described in this paper, it had been decided that it would be better to take a sufficiently large number of animals in any one year and subject them simultaneously to different nutritional conditions. A group of 60 heifers had been divided into 4 groups of 15. The groups had been fed in the following way: all groups received a basic diet containing an adequate but minimal amount of both calcium and phosphorus; Group I received only this diet; Group II received also a large excess of calcium; Group III a large excess of phosphorus and Group IV a large excess of both calcium and phosphorus. There were therefore a basic, a high calcium, a high phosphorus and a high calcium plus phosphorus group.

After the animals had been on the ration for a sufficient length of time, their fertility was assessed by up to 3 artificial inseminations. As the inseminations were given with semen from only one bull, it was considered desirable, although the semen was satisfactory by laboratory standards, to check the fertility of the semen by giving a further 3 inseminations from another bull, this time from the Reading A.I. Centre. As only a few more animals had held to the services by the second bull it could be taken that the semen used for the first inseminations was not the cause of the low fertility that was obtained.

In view of the fact that fertility in the first year had been low it had been thought desirable to repeat the experiment. In the second year the design was very much the same except that a group of animals had been added to act as controls. This group received an ordinary farm diet, the basic diet being unnatural and not one which was likely to be fed on a farm.

In the second experiment, natural service by 3 bulls had been used instead of A.I. A slide was shown of Table I in the paper and although the word "service" was used, in actual fact, one was A.I. and one natural service. Only the first 3 services were recorded and in the 1958 results no note had been taken of the fourth, fifth and sixth services which were intended merely to check the fertility of the Weybridge bull. For 3 services, it would be seen that the totals conceiving were very low in 1958.

It was not the purpose of the paper to explain, or attempt to explain, why fertility was low in 1958. The important point was that it was equally low in each nutritional group. The calcium-phosphorus ratio clearly had no effect on the fertility of the animals.

In 1959, the story had been quite different and a very satisfactory proportion had conceived to the first service in each group. The majority, if they had not conceived to the first service, had conceived to the second. The fertility based on the first 3 services was 100 per cent. in each group. Every one of them had conceived to the first, second or third services and there was no significant difference between the fertility of any of the groups. (*Slide.*)

Explaining the term "fertility rate," Miss Littlejohn said that each heifer was given a score which was the reciprocal of the number of services. If 1 service was required, the heifer had a score of 1; if 2, the score of a half; if 3, one third. When the scores were added up and the average taken, a fertility rate was obtained for each group.

It could therefore be said from the results of the 2 experiments that although the difference between the fertility in the 2 years was quite fortuitous—there was no magic way of determining whether there would be high or low fertility in the herd as a whole—the 2 experiments were complementary, and showed clearly that there was no difference whatsoever between the fertility of any of the nutritional groups.

Since the original suggestion had been made, that there was a relationship between the calcium-phosphorus ratio and fertility, Mr. Hignett had also discussed the possibility that other elements, notably manganese, might affect this. No attempt was made, in the experiment at present described, to influence the manganese content of the diet. The only elements with which the experiment had been concerned were calcium and phosphorus, but, naturally, the level of many dietary constituents had been noted, of which manganese was one.

It had been thought that it might be interesting to show a comparison between results obtained by Mr. Hignett over a period of 7 years and the results obtained in the 2 Weybridge experiments in 1958 and 1959. (*Slide.*) For example, Mr. Hignett had had 100 per cent. fertility in his Group D. In the animals falling into this group in the Weybridge experiment, 40 per cent. fertility had been ob-

tained in 1958 and 86 per cent. in 1959. Not all of Mr. Hignett's groups were represented in the Weybridge results, because none of the Weybridge heifers had a manganese intake of above 100 mg. per 100 lb. bodyweight, but in those groups where sufficient results had been obtained to enable a comparison to be made with Mr. Hignett's work, it would be seen that there was no correlation between the results obtained in 1958 or 1959 and Mr. Hignett's results. There was simply no connexion at all between the calcium-phosphorus ratio and the fertility of the animals, whether the level of manganese in the diet was considered or not.

An interesting thing which had not had much attention previously was that a supplement of calcium carbonate significantly depressed growth rate both in the fairly old animals used in 1958 and in the younger rapidly growing ones used in 1959. As might be expected, the growth rate was more rapid in 1959, when younger heifers were used than in 1958, but in both experiments, high calcium depressed the growth rate.

In view of the fact that Mr. Hignett mentioned a correlation between high growth rate and fertility in animals, it should be borne in mind that a high calcium supplement would depress the growth rate.

The Chairman then introduced Dr. E. W. Moodie.

Dr. E. W. Moodie, presenting his paper, said that since the symposium was on hypocalcaemia, he had tended to confine his remarks to that condition rather than to deal with the broader aspects of milk fever. No paper on milk fever would be complete without a consideration of a great many other factors, such as phosphate, magnesium and citric acid metabolism.

The first point he made was that hypocalcaemia in the bovine animal was not necessarily associated with evidence of clinical disorder. Hallgren in Sweden and his own colleagues under Professor Robertson at the Edinburgh school, had both reported the development of quite marked hypocalcaemia under experimental conditions without necessarily producing symptoms of milk fever; the former workers gave infusions of oxalate and the latter starved lactating cows. Thus, although milk fever was generally associated with hypocalcaemia, the converse was not necessarily true, and an adequate explanation had yet to be found.

The theme of the paper was that the milking cow was dependent on an uninterrupted mobilisation of calcium from both the skeleton and the digestive system. Fig. 1 indicated that the state of calcium exchange in the heavily milking cow was indeed precarious. Against a drainage of 15 to 35 g. milk calcium, 8 to 12 g. endogenous faecal calcium and 1 g. urinary calcium, could be placed an absorption of 15 to 30 g. calcium from the gut and an unknown amount from the bone. One estimate placed the bone exchange of calcium at 26 gm. per day in four sterile Jersey heifers of 3 years of age, but whether older cows could release calcium at anything like that rate was very doubtful, since it had been established that the lability of bone calcium decreased markedly with advancing years. Evidence suggested that a cow in full milk required to absorb 30 to 45 g. calcium daily into her circulation, and that this could not be obtained from the skeleton alone. Occasionally, a case would be met which succumbed repeatedly to hypocalcaemia during the first few weeks of lactation, and this might represent a cow unable to strike a proper balance between blood calcium input and output, but on the whole the normal aged cow in milk could regulate her calcium metabolism very efficiently, even during the peak of lactation.

There would appear to be no difference between the calcium output in the milk during the first few days of lactation in cows developing milk fever and in normal cows at that time; nor was there any evidence of an increase in urinary calcium output or any reason to suppose that endogenous faecal calcium altered at calving, although precise information on the latter point was not available. Consequently milk fever was often considered to be associated with a derangement in the input of calcium to the blood. Very little was known about mobilisation from the bone and attention, therefore, in the paper, was directed more to absorption from the alimentary canal. Two factors might operate at either of these sources to upset the rather fine calcium balance of the blood; a period might be required for adaptation to the new conditions after calving, which was a widely held theory, or there might be some factor operating to actively impede the replenishment of blood calcium.

The paper brought forward evidence that the alimentary absorption of calcium might be impaired, and he had suggested that a cycle of bowel inactivity leading to hypocalcaemia leading to further bowel stasis might be formed. Observations on a number of normal cows indicated that there was very little loss of appetite in young cows at calving but in older cows there was a reduction of approximately 50 per cent. in the food intake. Some evidence of upset of digestive activity was to be found in recordings of the ruminal movements of animals about to calve, where the waves of ruminal activity seemed to become weaker in some animals.

Evidence showed that an upset in mobilisation of calcium from the gut could produce a very pronounced hypocalcaemia. By starving aged cattle, Robertson *et al.* produced hypocalcaemia in 2 to 4 days but a more rapid effect could be produced by the use of drugs. Fig. 2 showed the effect of repeated injections of hyoscine on the serum calcium levels; in 2 dry cows and a young cow in milk there was no hypocalcaemic effect, while 2 older cows, 1 of which required treatment, showed pronounced reductions in serum calcium levels. The treated cow had calved her eighth calf and showed a pronounced fall in serum calcium down to milk fever levels; she was given a standard treatment of calcium borogluconate and recovered.

He suggested that the development of hypocalcaemia might be due to the following factors acting in unison:

(1) a high level of milk secretion;
(2) the decline of calcium absorption from the gut and bone associated with ageing;
(3) factors causing temporary arrestment of calcium mobilisation as, for example, stasis of the bowel.

The same principles might be applicable to cases of hypocalcaemia associated with digestive disorder and even to cases occurring in association with oestrus. On the other hand, loss of appetite associated with febrile symptoms was frequently associated with reduction in milk yield and no marked hypocalcaemia need be expected.

It was now apparent that it might be wise to choose methods of preventing hypocalcaemia which would operate even if absorption from the alimentary canal was impaired. The young cow presumably had adequate labile bone reserves to carry her over critical periods. In older cows, it appeared that the use of vitamin D supplements for 3 to 7 days might establish small deposits of calcium within the body, in addition to improving its digestibility, but such effects only prevented the development of hypocalcaemia for a few days after the completion of the therapy. Injected calcium salts likewise had a limited period of usefulness, probably lasting a few hours at most.

In conclusion, Dr. Moodie emphasised that the paper was concerned with calcium metabolism in the normal milking cow. While there was as yet little direct evidence that alimentary inactivity was a factor in the development of milk fever in cattle, it was clear that the heavily lactating aged cow was highly dependent on continuous absorption of calcium from the gut. No doubt further observations by clinicians and research workers would eventually elucidate the relative importance of calcium mobilisation from the bone and absorption from the gut in the aetiology of the disorder.

The opening remarks were illustrated by a series of slides.

Mr. J. B. White (Salisbury) referred to the recording showing the activity of the rumen at parturition and asked whether similar calcium estimations had been taken at the same time. It seemed to him a little difficult to assess whether the digestive upset came first or whether the drop in calcium provoked the digestive upset. It was well recognised, in treating a case of clinical milk fever, that the very first result obtained from an intravenous injection of calcium was the commencement of ruminal activity and the evacuation of faeces, which obviously meant that the "on-strike" muscle was beginning to work again.

Dr. Moodie, in reply, said that that was precisely the point which was being questioned in the paper. The

changes in alimentary activity and blood calcium were so close that it was very difficult to say which came first: it was suggested as a possibility (and only as a possibility) that there might be some stasis or interference of gut activity leading to a lowering of serum calcium and a further reduction in gut activity, thus forming a vicious circle. The primary cause could quite readily disappear and the animal recover on straightforward calcium infusion. In one or two animals it had been noticed that the appetite fell before there was any drop in the serum calcium below physiological limits, but he could not go beyond that at the moment.

Mr. D. Wright (Lichfield) asked whether the actual clinical symptoms observed in hypocalcaemia were due to the lowering of the blood calcium or to one of the other factors indicated in the paper. One found that if blood samples were taken, one could get a cow which was only slightly ataxic showing a calcium level of 2 mg. per cent., or even less, whereas a cow in lateral recumbency, almost on the point of death, might have a calcium picture of 5 or 6 mg. per cent. It did not seem to add up.

Another feature which he could not understand was that if, as he had done on several occasions, a veterinary surgeon ran out of calcium borogluconate, he could give an organic phosphorus preparation without calcium (Duophos) and the cows usually got up.

Dr. Moodie, replying, said that he thought the business of milk fever was not a straightforward hypocalcaemia. Those who knew of the earlier work of Professor Robertson at Edinburgh, and other workers, felt the same way—that hypocalcaemia was not the whole story in cases of milk fever.

With regard to the question of animals recovering from phosphate injections, it was a little hard to understand. It was known that there were cases which recovered spontaneously, but whether that had occurred in the cases treated by Mr. Wright, he could not say. There were suggestions that hypophosphataemia might be a complicating factor in milk fever, but he kept an open mind on that particular point.

Mr. K. N. Burns (Weybridge) said there was often the same lack of relationship between symptoms and blood levels in hypomagnesaemia and calcium injection intravenously would usually relieve the acute symptoms.

Dr. W. A. Greig, presenting his paper on "Calcium-Iron Relationships in Fattening Pigs," said that although the title of the symposium was "Calcium metabolism" his paper did not deal with calcium metabolism in the strict sense, but rather with the effect of a calcium salt on the metabolism of another metal, iron.

The series of experiments summarised in the paper began with some work he had carried out when he was a member of the staff of the Rowett Research Institute in Aberdeen. The initial work had been done on mice, and the main finding was that if calcium carbonate were included as a supplement to a basic diet it interfered with iron absorption, so causing anaemia and poor weight gain. This was particularly evident in the offspring of mice which had been fed the supplement when pregnant.

The deleterious effects of the calcium supplement could be overcome by administering iron, either in the diet or by injection. Provided that iron intake was sufficient, calcium carbonate did no harm. There was a certain balance between them; it was not linear but the more calcium in the diet the more iron was needed to avoid anaemia.

It was well recognised that iron was a very important substance to the young piglet, and for that reason the observations in mice had been extended to pigs. First of all, the experiment was repeated on pigs by feeding calcium carbonate to pregnant gilts and sows. Their ordinary diet contained a fairly large amount of iron, so a large amount (6 per cent.) of calcium carbonate was added to the diet. Nothing very striking had happened. There were some mild digestive disorders in some of the animals fed this large amount, but no anaemia; and the young pigs born from the mothers receiving the high calcium were as good as the pigs from those receiving none at all. They were as numerous and they were as heavy. Furthermore, their mean haemoglobin levels were more or less identical.

It appeared that a new-born pig was deficient in iron in any case, so from this point of view it did not matter very much whether the mothers were given large amounts of calcium carbonate or not.

It was important to remember the essential points about the metabolism of iron. It was a curious substance in that its level in the body was controlled by absorption and not by excretion. Indeed, the body had no mechanism for ridding itself of iron. Thus, even if an animal could not absorb iron, no harm would result unless there was a demand for more iron for some reason or another. The usual reasons for requirements of iron being increased were growth, pregnancy and lactation. The iron stores were generally adequate to take care of any small additional requirements, but when these were large the iron stores would not last out. So long as they lasted, the animal would not become anaemic and would not lose weight.

Having found that calcium carbonate made no appreciable difference to the haemoglobin levels of young pigs or sows, he had then turned to consider fattening pigs. In these the results of iron might not be so high as in adult sows or gilts that had been turned out to grass, where there was ample opportunity for them to have built up their reserves with iron from the soil.

Sixteen female pigs from two litters had been fed on the same diet as the mice. (*Slide.*) This was not a very natural pig diet, consisting mainly of wheat with dried milk added. Half of the pigs in each litter were fed this basic diet alone, the other half-litters being fed a 2 per cent. supplement of calcium carbonate. The results were shown on the slide. The calcium carbonate supplement had definitely depressed the haemoglobin levels. It could also be seen that the pigs receiving the supplement were, if anything, slightly the heavier at the beginning, but they were distinctly lighter at the end of the trial. There was in fact no significant difference between them at the beginning, but there was a significant difference at the end.

(*Slide*). When the half-litters in each group were compared, it was found that the mean haemoglobin levels of both half-litters were affected by the supplement to about the same extent. With regard to weight, however, the difference was much greater in one half-litter than in the other.

It had struck him as a possibility that the low weaning weight of one litter might have been of importance, so the point was examined more fully. There were other possibilities: it might have been that the initial haemoglobin was the factor involved because the initial haemoglobin of one litter was a great deal lower than that of the other. There might have been inherited differences. It might have been a question of the iron reserves.

When the question had been studied statistically, however, it had turned out that initial weight was the most important factor. The method was briefly as follows:

The initial weights of all the pigs had been assumed to be the mean weight of 32 lb. (*Slide.*) By means of regressions worked out on this basis, the calculated differences between the groups at both 4 and 8 weeks proved to be very highly significant. On the other hand, there were no important differences between the half-litters in each group. This would suggest that inherited differences were of little importance in this matter. The reason for the original litter differences appeared to lie in their different initial weights, and his guess had been that this was related more or less to the level of iron stores.

The question of iron stores had later been studied very fully. First, however, another experiment, using 20 pigs from two litters, had been done. This was a factorial experiment, and permitted direct examination of several factors which might have played a part: the supplement of calcium; the litter factor; the sex factor; initial haemoglobin; and initial weight. This time a much more natural basic diet was used, and 5 per cent. of calcium carbonate added as a supplement to one group. This was obviously not a realistic figure from a practical point of view, but it was necessary to know whether or not effects were demonstrable at those high levels.

Most of the factors had proved to have some bearing, on whether the calcium carbonate affected haemoglobin level and growth rate, but by far the most important factor was

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the initial weight of the animal. (*Slide.*) In animals which had a high weaning weight of over 50 lb. the calcium carbonate had no effect; in those with a low weaning weight, the differences were obvious.

He suspected that growth rate was a reflection of what had happened to haemoglobin; but one could not compare the two at the same time, because the growth rate would be related to the haemoglobin levels existing over the past little while.

It seemed likely that if the harmful effects of calcium carbonate were mediated through an induced deficiency of iron, the special susceptibility to it of pigs with a low weaning weight could be accounted for by impoverished stores of iron, insufficient in amount to meet the animals' requirements under conditions of minimal iron absorption. This view was supported by the finding of a significant correlation between initial weight and initial haemoglobin, indicating that, in general, the lightest pigs also had the lowest haemoglobin values.

Nevertheless, calcium carbonate might also have had some other more direct effect. To decide this point, 20 weaning pigs were taken and divided into 4 groups of 5. All were fed good quality meal, but 2 groups received a 4 per cent. supplement of calcium carbonate. The pigs in one of these groups and also those in one of the unsupplemented groups were each given iron dextran intramuscularly at weaning and again 4 weeks later. At the end of the eighth week, the pigs receiving calcium carbonate but no iron were distinctly lighter than those in other groups. The iron injections appeared to have exerted a protective influence, however, for the iron-injected pigs, even though receiving calcium carbonate, were as heavy as the controls. This result had shown that the depressing effect of calcium carbonate on rate of live-weight gain could be overcome by providing sufficient iron, and it followed that it must be mediated, at least in the main, through a conditioned iron deficiency.

The possibility had been considered that iron deficiency in fattening pigs might be a factor in the failure of the animals to show full growth potential, whether or not they were receiving calcium carbonate. Two interesting, small-scale trials in pigs had been conducted in which injections of iron dextran had been administered at weaning time to half the pigs in a number of litters, and the subsequent growth weight of the pigs followed up to 4 to 8 weeks after weaning. The results given in the paper suggested that, even if animals were not fed calcium carbonate, the growth rate could occasionally be improved quite distinctly, and to a statistically significant extent, simply by ensuring that the animals got enough iron.

Having established the effects of large supplements of calcium carbonate, the practical proposition of whether small supplements produced similar effects had been investigated. There was distinct evidence that, in some cases, usually in pigs with a lowish weaning weight and with low iron stores, even 2 per cent. of calcium carbonate could very significantly reduce both haemoglobin level and, subsequently, rate of live-weight gain. The results might not be spectacular; it was not a question of the animals living or dying. It was a question of their realising their full economic potential. In days when margins in the pig-farming industry were small, every little helped.

Dr. T. A. Douglas (Glasgow) asked how the figures of 2 per cent. and 6 per cent. of calcium carbonate had been arrived at. The figure of 2 per cent. was for mice, whereas for pigs it was 6 per cent. in the diet. Were those figures comparable from one species to another? If the control group in the mice had been fed something like sodium bicarbonate or sodium carbonate, would that have eliminated the possibility of the defects described, being due purely to the antacid effect? What was the effect of feeding calcium chloride?

Dr. Greig, in reply, said that, in the first instance, the 2 per cent. level was quite arbitrary. The figure had been chosen and found to work with the mice. Two per cent. had been added to a pig meal fed to mice, but with little effect. The reason for that had been made clear when the iron contents of the 2 diets had been examined. The original mouse diet had a relatively low iron content diet, while that of the pig meal was very high. It had been realised that, in order to get large and significant differences a large amount of calcium carbonate would have to be used, and 6 per cent. was chosen. This seemed to be the proper method of approach: first of all, it had to be discovered whether any level of supplement would be effective; having established that this was so, the levels at which it was important had to be established. For that reason, 6 per cent. had been chosen for the pigs in the first instance, but later that had been cut down to levels such as 2 per cent. which were more realistic from the point of view of everyday feeding practice.

Regarding other substances, several had been used with mice and quite fully worked out. All sorts of calcium salts had been used and also all sorts of other alkaline materials. Calcium carbonate was not the only substance which produced the effect, but certainly the effect of sodium carbonate was nil. He had wondered whether mice would eat washing soda, but, in fact, they had seemed to lap it up! It had no effect whatsoever on the blood haemoglobin concentration or the rate of live-weight gain in the mice.

Broadly speaking, he had found that calcium, magnesium, sodium and potassium compounds fell into two categories: the sparingly soluble substances and the readily soluble substances. The sparingly soluble substances all diminished iron absorption, but the others had no effect. The reason was that a high *p*H resulted in diminished absorption of iron from the last part of the stomach and the first part of the small intestine. An antacid substance like calcium carbonate lingered in the stomach for some time because it was sparingly soluble, and so created antacid conditions there; and iron could dissolve in any quantity only at a *p*H value not above about 5. The antacid properties of calcium carbonate thus prevented iron absorption. However, sodium carbonate and the other readily soluble salts passed on rapidly from the stomach to the small intestine.

Mr. J. R. Campbell, presenting his paper "The Effects of Calcium and Phosphorus Deficiency on Bone Growth in the Dog," showed several X-ray plates and slides in order to illustrate some of the points in the paper.

The first group of plates showed the radiographic appearance of the bones of several animals which were presented at the Hospital with the diagnosis of rickets. They all showed, in varying degrees, the typical rachitic syndrome of lameness, distortion of the limbs, and enlargement of the joints. On the radiographs of these animals it could be seen that there were definite abnormalities of the bones, but in the majority of cases, there was no enlargement or distortion of the epiphyseal cartilage—*i.e.* the animals were not suffering from true rickets (see Plates I & II).

The plates of 5 clinical cases of this type were shown, and it was noted that in no case were the blood mineral levels found to be lower than normal. Most of the animals were being fed large quantities of vitamin D.

One plate was shown of an animal which was considered to be 1 of only 3, admitted to the Hospital in the last 10 years, in which the radiographic appearance of the bones was in any way similar to true rickets.

The final plate in this group showed the radiographic appearance of the limb bones of a 5-month-old Dalmatian, which again showed symptoms similar to rickets, but which, on radiological grounds, was diagnosed as a case of infantile scurvy (Barlow's disease). Although no vitamin C estimations were carried out, treatment with vitamin C produced a dramatic remission of pain and lameness, and healing of the bone lesion was verified by radiography one month later (Plate III).

The next group of plates illustrated the fact that, while both low-calcium and low-phosphorus diets produced rachitic changes, the radiographic appearances of the bones were different. Plates of the limb bones of animals subjected to a low-phosphorus diet showed mainly extreme overgrowth of the epiphyseal cartilage, with little distortion of the metaphysis and virtually no excess density at the area of provisional calcification (Plate IV). The bones of animals on a low calcium diet, on the other hand, while showing less marked cartilaginous overgrowth, were more severely deformed at the metaphysis. In these animals, however, mineral deposition seemed to be taking place at the zone of provisional calcification (Plate V).

Finally, slides of histological sections of bones from animals in the 2 groups were shown. The animals on the low phosphorus diet showed thick, irregular, uncalcified masses of osteoid tissue contiguous with the widened, irregular, epiphyseal line (Plate VI). The bone trabeculae of those on the low calcium diet, although more normally mineralised and of more normal dimensions, were few in number and very irregularly arranged (Plate VII).

The Masson stain, which was used for these sections, will, if the technique is carefully carried out, show the uncalcified osteoid blue while the calcified bone stains red.

Mr. Campbell finished by saying that recent experiments had agreed with the findings of previous workers that although vitamin D might not be the most effective treatment in advanced rickets, it did prevent the condition if administered to animals as soon as they were subjected to a deficient diet.

The General Discussion

Mr. K. O'Sullivan (Milk Marketing Board) commented that some of the heifers were 4 years old. In normal farm practice, that would not be considered a very good idea. There might be some excuse for taking heifers and starting to breed them at 4 years old. It was an age when one would expect them to be less sensitive to changes in their calcium-phosphorus ratio. Had Miss Littlejohn any information on the fertility of the heifers according to age in the different groups?

On the question of inseminations, had one person performed all the inseminations? What was the rate of dilution of the semen?

Miss Littlejohn, in reply, gave reasons for the use of animals of 4 years of age. The reason the animals were old was that they were obtained from a very strictly controlled source—4 farms that Mr. Lawson had known personally for a matter of 10 years, during the greater part of which time they had been free from any infectious disease that might affect fertility. The herds were rather small. The experiment required a large number of heifers—60—which could not all be obtained simultaneously from those herds. The owners had therefore been asked to set aside their surplus heifer calves for Weybridge over a period of time, so that, although some animals were only 2 years old when mating started, some were over 2 years old, and 2 were actually 4 years old. That was the reason for the animals being a good deal older than was usual under farming conditions in this country.

It should be mentioned, however, that there was no significant reduction in fertility in the older heifers compared with the younger. In fact, the older heifers were very slightly better than the younger ones, but the difference was not statistically significant.

Insemination, unfortunately, was not carried out by the same operator. The writer was not aware that it would be possible, in a democratic society, to have the same operator available over the whole of the period that the services were required. Some other countries might manage these things better, but people did have summer holidays. Five or 6 different workers had carried out the A.I. Even when the Reading A.I. Centre had carried out the check inseminations, it was not always the same operator who came.

With regard to dilution of semen, she could not say what this was offhand because one of her colleagues had collected and prepared the semen, but the details were given in the paper.

Dr. W. R. Wooldridge said that there were so many chemical reactions going on in the body, and so many variables, that he would like to know if the authors considered that they had a sufficiently large number of animals in their experiments to justfy forming firm conclusions.

Miss Littlejohn replied that the answer was "yes". In view of the fact that many people made pronouncements on very much smaller numbers of animals, 15 was felt to be quite a reasonable number, particularly considering the amount of money the taxpayers had to pay for those heifers.

Dr. Wooldridge agreed that the numbers were rather better than usual, but he personally did not think that they were sufficient to cover the variables. For example, if the 2 years' work was summed up and averaged, results would be very similar to those of Mr. Hignett, yet they were markedly different. He thought a very much larger group of animals was needed before a statistically valid conclusion could be reached.

Miss Littlejohn, in reply, said that many variables were intentionally not considered; consideration had been deliberately restricted to calcium and phosphorus. Naturally, information was available about many of the other minerals, but the experiment was not concerned with their effect. Any effect they might have had must have been equally felt in all the groups because, as far as possible, the animals were kept in identical conditions. Conditions had been standardised very carefully in both years. According to the statisticians, the results were significant.

Miss C. M. Ford suggested that there was a misprint under "Diet" in Miss Littlejohn's paper where calcium oxide was given as 15.7 g. Surely, that should be 157.0 g.? Also, in the next paragraph, Ca was written where it should be CaO.* Surely the results were that the differences between the groups were not significant?

Miss Littlejohn said that the numbers of animals were adequate to ensure that the lack of significance between results was valid.

Miss Ford said that that was very different. If there were no significant differences, that did not prove anything. If there were significant differences, it might prove something.

Dr. Wooldridge said that the main object of any experiment where there were controls was to reduce the variables to one. On putting the problem to a statistician he must be told all the variables in a particular problem before he was in a position to suggest statistically valid experiments or to tell whether those already done were statistically valid.

Mr. J. Hancock said that the point in question was the sensitivity of the experiment and what sort of differences could be detected using those particular numbers.

Miss Littlejohn said that, while agreeing with those principles, if the mineral ratios were going to influence the fertility, it would come out in the intergroup comparison for each year.

The Chairman said that though the papers had been tenuously linked together with the common bond of calcium they were different in many ways and did not constitute a true symposium. A study of calcium metabolism was, however, of greatest importance to veterinary science and some of the work described in the papers was likely to provide answers to questions which had been put a long time ago. It was important to realise that many were presentations of work still in the pipeline and the final results of some of the investigations could not be expected for a considerable time.

The meeting was very grateful to those who had presented the papers on this important subject.

* These corrections have been carried out in the text.

FOOT-AND-MOUTH DISEASE

Restrictions on the movement and marketing of livestock in the Infected Area around Middleton-on-the-Wolds, Yorkshire (East Riding) have been withdrawn as from December 7th.

The two outbreaks in this Area involved the slaughter of 133 cattle, 850 sheep and 31 pigs.

The Scientific Exhibition at the Glasgow Congress

FOLLOWING the precedent set 3 years ago at Cambridge, a feature of this year's Congress was a scientific exhibition. The exhibition was organised by Dr. Alastair Greig, and was declared open by the President on the morning of the first day of Congress, remaining open daily throughout Congress week.

Practically every branch of veterinary work was represented; and it was particularly satisfactory to find that, while there was of course much to interest the specialist research worker, the general practitioner had by no means been forgotten: indeed fully half of the exhibits related to subjects of direct clinical significance.

Good examples of this type of exhibit were those dealing with applied anatomy, all of which reached a very high standard. Mr. McCallum demonstrated the location of nerves commonly blocked for purposes of regional anaesthesia and also displayed magnificent enlarged colour prints showing the topography of organs in the diaphragmatic region of the ox. Mrs. Lindsay's exhibits dealt mainly with applied osteology, including radiographic appearances, and Mr. Taylor displayed several clear and meticulously documented dissections of the bovine foot and the lower parts of the limbs, which illustrated his contribution to the symposium on diseases of the bovine foot held during the week. Dr. Findlay and Mr. MacEwan Jenkinson demonstrated the micro-anatomy of various parts of the bovine integument.

Amongst other exhibits of particular interest to practitioners were two on hypomagnesaemia. That by Professor Inglis and Dr. Hemingway dealt with the effects on sheep serum magnesium levels of various factors such as climatic conditions, pasture management and manurial treatment, the chemical composition of the pasture, indoor and outdoor feeding, lactation and age. In common with Dr. Watt's exhibit it also demonstrated the wide individual variation which occurs in ruminant serum magnesium values.

In the field of calcium metabolism, Dr. Greig showed that hypervitaminosis D, resulting from the use of an injection designed as a prophylactic against milk fever, led to widespread sub-intimal calcification in the heart and large blood vessels. This exhibit made use of an effective apparatus by which a series of slides, changed automatically at pre-set intervals, was projected into a daylight viewing box.

Dr. McPherson's display was concerned with ringworm in various species, and included remarkable colour photographs of fluorescence under Wood's lamp; the other ringworm exhibit, by Messrs. Lauder and O'Sullivan, illustrated their notable work on the successful use of griseofulvin in the treatment of this condition.

Miss Leahy and Mr. Lawson displayed a large number of radiographs, which amply demonstrated the great assistance that modern radiological techniques can offer to the clinician. A most interesting collection of electrocardiographic tracings exhibited by Mr. Glazier and Professor Kelly illustrated the value of another type of ancillary aid to clinical diagnosis.

Other clinical contributions included Mr. Owen's comprehensive exhibit on bone tumours in dogs, and a demonstration of urinary calculi by Professor White and his colleagues. In another field of surgery Mr. Cook demonstrated the technique and applications of rhinolaryngoscopy in the horse.

The Glasgow Veterinary School research team whose members have been responsible for the development of an irradiated vaccine against parasitic bronchitis put forward an exhibit on this disease. It illustrated the life cycle of the bovine lungworm and various stages in the experimental studies culminating in the production this successful vaccine. Helminthiasis and its relationship to the wild ruminant in Scotland was the theme of another exhibit from Glasgow by Dr. Dunn.

In the field of pathology were contributions from the Royal (Dick) School of Veterinary Studies, Edinburgh, dealing with actinobacillosis, nocardiosis and mast cell tumours. Mr. Campbell and his Glasgow colleagues dealt with experimental coronary arterial disease; and from Yorkshire there was an extensive exhibit on toxoplasmosis by Mr. Watson and his collaborators.

One of the most admired displays was that contributed jointly by the various artificial insemination organisations in Great Britain. It indicated the extent and scope of artificial insemination in cattle in this and other countries. Another part of the exhibit dealt with artificial insemination in the pig. There was also interest for practitioners in Dr. Soltys's demonstration of a modified Leifson's method of staining capsulated anthrax bacilli after bactericidal treatment with Zenker's solution, and in Mr. Lucas's illustration of the effects of amicarbalide in the treatment of redwater in cattle.

An item of apparatus which, in view of the importance to mastitis control of milking machines in proper working order, may well prove to have useful application in the field was Mr. Wilson's vacuum recorder. When visitors pressed a switch the apparatus recorded on paper the pulsation characteristics of a milking machine to which it was connected.

Mr. Wilson and Dr. Owen, showed a most attractive exhibit dealing with cobalt pine and the prophylactic use of cobalt bullets in sheep, and including examples of the incrustations which, under certain conditions, may grow on the surface of the bullets.

Some exhibits, however, were clearly intended to be of primary interest to fundamentalists and research workers rather than practitioners. For example, Messrs. Anderson and Pickering demonstrated the application of glomerular filtration rate measurement to the estimation of the renal clearance of sodium, potassium and bicarbonate in adult cows. In a similar category was Mr. Sanford's demonstration of the distribution of histamine in the sheep abomasum

(*Concluded at foot of page opposite*)

Current Literature

ABSTRACT

Antibiotic Sensitivity of Staphylococci from Noses of Veterinary Surgeons and Farmers. SMITH, H. WILLIAMS, & CRABB, W. E. (1960). *Lancet*. **2 (1960).** 515.

Nasal swabs were taken from 200 veterinary surgeons and 200 farmers. Farmers were chosen as the control group because their environment approximated most closely to that of veterinary surgeons with the exception that they would not normally have nearly so much contact with antibiotics. Of the veterinary surgeons 34 per cent. were found to be carriers of *Staph. aureus*, while in the farmers the figure was 38 per cent. Of these carriers penicillin-resistant strains were recovered in 88·3 per cent. in veterinary surgeons and 21 per cent. in farmers. Expressed as a percentage of the total number of veterinary surgeons penicillin-resistance was found in 30 per cent.; in the case of the farmers the figure was 8·0 per cent. Resistance of *Staph. aureus* to tetracyclines, streptomycin, or chloramphenicol, was found in 14·7 per cent. of the veterinary surgeon carriers and 2.6 per cent. of farmer carriers.

The high incidence of resistant strains in veterinary surgeons is probably related to the fact that they handle antibiotics frequently. This suggests the need for more stringent precautions in the handling of antibiotics during the treatment of animals. G.F.B.

The Scientific Exhibition at the Glasgow Congress.—*Concluded*

and its inhibitory action on smooth muscle; while a unit of working apparatus that attracted much attention was Mr. Davey's artificial rumen, whose metabolic activity under various conditions closely simulated that of the natural organ.

The specialist microbiologist was also well catered for. Contributions from the Wellcome Research Foundation and the Pathology Department of Glasgow Veterinary School dealt with such varied items as modern techniques in virology, including tissue culture and haemadsorption; antibody response to the injection of viruses; the laboratory diagnosis of leptospirosis in pigs; and the highly complicated subject of the identification and differentiation of clostridia and their antigens. A method, demonstrated by Dr. Foggie and Mrs. Hood, by which the tick-borne fever virus can be adapted to laboratory animals utilised a technique which may well prove to have wider implications.

Another interesting and very welcome exhibit was that submitted by the Department of Veterinary Services, Kenya; this illustrated some of the recent achievements of its research laboratories, including the production of vaccines against Newcastle disease, lumpy skin disease and sheep pneumonia. The Department's Director, Mr. McOwan, is to be congratulated on his initiative in preparing and sending such an excellent and attractive stand. It was unfortunate that circumstances of time, distance and availability of personnel forced the withdrawal of two other intended exhibits from Africa.

BOOKS RECEIVED

Instinctive Living—A Study of Invertebrate Behaviour, by T. Savory. Pergamon Press. London (1959). 17s. 6d.

Lymphatics and Lymph Circulation—Physiology and Pathology, by I. Rusnyák, M. Földi, and G. Szabó. Pergamon Press. Budapest (1960). 140 s.

Die Narkose der Tiere. Band 1—*Lokalänasthesie*, by M. Westhues and R. Fritsch. Paul Parey. Berlin (1960). 25.80 DM.

Papers dedicated to Dr. Nicolai Plum on the Occasion of his Seventieth Birthday. Various authors. Carl Fr. Mortensen. Copenhagen (1960).

The Structure of the Fowl, by O. C. Bradley, revised by T. Grahame. Oliver and Boyd. Edinburgh (1960). 25s.

An Introduction to Embryology, by B. I. Balinsky. W. B. Saunders. London (1960). 54s.

Studies of Vertebrate Neurogenesis, by S. Ramón y Cajal. Blackwell. Oxford (1960). 106s.

An Introduction to Animal Biology, by D. C. Braungart and Rita Buddeke. C. V. Mosby. St. Louis (1960). 47s.

Mackie and McCarthey's Handbook of Bacteriology—A guide to the Laboratory Diagnosis and Control of Infection. Edited by R. Cruickshank. E. & S. Livingstone. London (1960). 40s.

Aspects of the Origin of Life. Edited by M. Fiorkin. Pergamon Press. London (1960). 30s.

Animal Husbandry Heresies, by A. Fraser. Crosby, Lockwood. London (1960). 16s.

Farm Animals in Health and Disease, by W. R. Wooldridge. Crosby, Lockwood. London (1960). 35s.

Orthopaedic Surgery of the Dog and Cat, by E. P. Leonard. W. B. Saunders. London (1960). 87s. 6d.

Henderson's Dictionary of Scientific Terms. Edited by J. H. Kenneth. Oliver and Boyd. Edinburgh (1960). 32s.

The Female of the Species, by R. H. Smythe. Country Life. London (1960). 21s.

Farm Animals—Their Growth, Breeding, and Inheritance, by Sir John Hammond. Edward Arnold. London (1960). 28s.

A Short History of Veterinary Medicine in America, by B. W. Bierer. Michigan State University Press. Michigan (1955). $3.

Calendar of the Pharmaceutical Society of Great Britain 1960-61. Pharmaceutical Press. London (1960). 20s.

Radiography for the Veterinary Surgeon, by R. N. Smith. John Wright. Bristol (1960). 13s. 6d.

Lokalänasthesie—Anleitung fur Tierarzte, by I. I. Magda. Gustav Fischer. Jena (1960). 33.60 DM.

Anatomy and Histology of the Eye and Orbit in Domestic Animals, by J. H. Prince, C. D. Diesem, I. Eglitis, and G. L. Ruskell. Charles C. Thomas. Springfield (1960). 126s.

Cutaneous Innervation. Edited by W. Montagna. Pergamon Press. London (1960). 63s.

Atlas der Pathologisch—Anatomischen und Histologischen Diagnostik der Schweinpest, by H. Rohrer

and K. H. Pehl. Gustav Fischer. Jena (1960). 44.50 DM.

Calf Rearing—Ministry of Agriculture Bulletin No. 10, by T. R. Preston. H.M.S.O. London (1960). 3s.

REPORTS

British Empire Cancer Campaign. Thirty-seventh Annual Report, covering the Year 1959. Part 1: The Chairman's Statement and the Accounts, pp. i—xxxviii. Part II: The Scientific Report, pp. xli —liv, 1—666.

The general criticisms of the last Report (Vet. Rec. 1959, p. 723) apply with equal force to this present Report. In particular, the Report is still rendered almost unusable and almost worthless by the absence of a subject index. The reviewer will not, however, go over all that ground again, and will content himself with quoting a few items (which caught his eye at a first reading) that may be of particular interest to the veterinary reader:

P.80: E. Boyland and colleagues report in their studies on the metabolism of carcinogens: "Examination of the urine of dogs dosed orally or parentally with 2-naphthylamine showed no qualitative difference between the known metabolites excreted. This finding differs from our previous results in another group of dogs. In these, 2-amino-1-naphthylglucosiduronic acid was detected in the urine of dogs after oral administration but not after subcutaneous injection."

P.128: In reference to their studies of naturally occurring radioactivity, W. V. Mayneord and colleagues report: "Measurements have been made on the levels of radium and thorium in the bones and soft tissues of a number of animal species. In general the bone activities are considerably greater than those found in man as also are the activities in the liver, kidney and eyes of the cow and sheep. The distribution of radium and thorium in these animal tissues is being studied in relation to the data emerging from the studies of vegetation and soils."

P.241: In an experimental study of localised hypothermia of the liver for the surgery of malignant liver disease, M. F. Nicholls and colleagues report: "Acute experiments on the cat and goat showed:—(i) That obstruction of the portal vein was fatal after 30 minutes in the absence of hypothermia. (ii) That local cooling to 23°C. prolonged survival. (iii) That electrolyte changes were slight and inconstant. Survival experiments were then commenced on calves at the Buckston Brown Farm. Experiments were in two stages:—(i) The portal blood was cooled to 15°C. and rewarmed, but the circulation was not occluded. All calves survived, and after 3 to 6 months there was histological or biochemical evidence of liver damage. (ii) The liver was cooled to about 15°C. and the hepatic and portal circulation occluded for periods up to 30 minutes. All these calves died in the post-operative period, and all showed excessive bleeding tendency."

P.319: In a study of the comparative aetiology of bone sarcomas, C. H. G. Price reports that "an analysis has been made of the series of osteogenic sarcomata in dogs reported in U.S.A. by Brodey *et al.* (1959). Broadly there is close similarity to the British material . . . both series show that apart from the small class of rib tumours, the crude age distribution curve of canine osteogenic sarcoma is monomodal—not bimodal as observed in man in the United Kingdom. There is also a tendency for osteogenic sarcoma to appear rather earlier in life with increasing size of breed of dogs, the mean age of appearance of tumours being about $6\frac{1}{2}$ years for the large breeds, $7\frac{1}{2}$ years for the medium-sized breeds, and around 9 years for small breeds . . . there appears to be a logarithmic function relating body size and mean age of appearances of these tumours."

P.340: "I. A. Silver, of the Department of Veterinary Anatomy of the University of Cambridge, has used tritiated Synkavit [tritiated tetra-sodium 2-methyl-1, 4-naphthohydroquinone diphosphate] in the treatment of certain spontaneous tumours of animals."

P.344: "4 dogs, clinical cases of spontaneous osteosarcomata, one dog with a tumour of the skin, and a cat with a carcinoma of the tongue have been treated with intra-arterial tritiated Synkavit. In each case the growth of the tumour was temporarily arrested. In the cat with the carcinoma of the tongue the growth disappeared completely and did not recur for 3 months. The dogs . . . had to be destroyed because the tumours started to grow again."

P.429: A. and P. R. Peacock have made a search for a natural source and for a possible natural intermediate host or vector of the infective virus of spontaneous sarcomas of fowls.

P.442: A. W. Greenwood and colleagues report: "The control hens in the long-term experiment which resulted in complete mortality from adenocarcinoma in sibs maintained under a standardised environment are approaching the end of their 8th year of life. Of the original 18 birds in the group, 12 are still under observation, 7 maintained under normal intensive management and 5 confined to the climatic chamber over the past 3 years. During the year 1 tumour only developed in the pen controls—a rare osteogenic sarcoma. To test the hypothesis that adenocarcinoma developed from abnormally prolonged reproductive activity with resultant long-continued stimulation of the oviduct by endogenous oestrogen in birds kept in a constant environment, a replicate experiment was designed in which dienoestrol diacetate was included in the diet from time of hatch. After less than 3 years in the standardised environment 1 hen succumbed to an adenocarcinoma typical of the original group. Of controls receiving artificial oestrogen, 1 female showed a plasma cell myeloma on examination *post mortem*."

P.443: "In a study of the rare spontaneous cases [of neurolymphomatosis] arising in the P.R.C. flock no virus particles were detected [in electron microscope studies] in the affected nerves, but some submicroscopic changes in the nerve fibres were noticed (disintegration of the myelin sheath, and thickening of the fibrils). It was also found that the characteristic nerve swelling is due, at least partially,

to formation of large amounts of collagen between the nerve fibres."

P.445: "A further series of cases of spontaneous sex reversal in hens has been examined. It is confirmed that such birds have a characteristic BSP clearance which appears to be associated with hyperoestrogenisation and the subsequent histological examination of the gonads (which may be in the form of an ovotestis containing various amounts of sertoli, granulosa, thecal or arrhenomatous elements) and the examination of other organs such as oviduct, kidney and adrenal, confirms this."

P.448: In Kampala, C. Jackson reports: "Studies have been carried out of animal tumours using cytological techniques, the methods being similar to those of exfoliative cytology whereby films are obtained by teasing, spreading, smearing or concentrating tumour cells. Pathological diagnosis of many tumours can be made in a few minutes and the cells can be more closely studied and characterised. Detailed studies have been made of cases of the transmissible venereal tumour of dogs with special attention to the identification of infiltrating cells and to the presence in the tumour cells of chromatic cytoplasmic inclusions. These bodies appear to stand in relationship to the chromophobe vacuoles which have in the past been described in these cells."

P.508: From the Department of Pathology, University of Melbourne, Anna Jabara reports: "The investigations into mammary tumours of the dog (both of naturally occurring growths and experimentally induced tumours) have been continued. A considerable series of both mixed tumours and mammary carcinoma have been examined and recorded. Various side effects following the injection of stilboestrol have been investigated and tumours of the ovary, developing in these animals, are being studied."

P.592: From the Department of Pathology, University of Hong-Kong, Pao-Chang Hou and colleagues report: "Liver from experimental cats infested and non-infested with *Clonorchis sinensis*. The copper level in the tissues from highly infested liver was found to be the lowest; and from moderately infested liver, lower than that of non-infested . . . From [our] findings, it is reasonable to conclude that the worm (sic) requires a high level of copper in its environment in order to maintain its physiological functions . . . Whether or not this requirement of the worm affects the body economy, particularly in the liver and the bile, and consequently affects the enzymatic activity of the epithelial cells in the bile duct, leading to eventual hyperplasia or anaplasia, is a question that remains to be investigated." E.C.

Animal Research Division of the New Zealand Department of Agriculture: Annual Report 1958-59.

New Zealand's chief sources of overseas income are her 40 million sheep and 6 million cattle. With such valuable assets to safeguard it is understandable that research into the problems of breeding, nutrition, management, and disease, should be given a good deal of attention. This work is conducted mainly at the Department of Agriculture's 2 animal research stations at Wallaceville and Ruakura, both in the North Island, the former dealing mainly with the diagnosis and control of animal disease and the latter with animal breeding and management. This 1958-59 Report gives in broad outlines and without a burden of detail, an excellent indication of the wide variety of problems being tackled and the types of experiments in hand.

Sheep breeding projects included studies on the fecundity of Romney sheep, on improving the fertility of Romneys by cross-breeding with Border Leicesters, on the fate of ova after tupping in order to try and explain low lambing percentages in maiden ewes, and on the possible hereditary basis of "bearing" disease (prolapse of the vagina).

Other trials were conducted on the effect on fertility of shearing—only 6.4 per cent. of ewes shorn immediately before joining with the rams failed to lamb compared with 22.5 per cent. of ewes not shorn —and of various systems of management.

Interesting and significant results were obtained in a number of nutrition experiments, particularly in regard to "white muscle disease" (muscular dystrophy) in lambs and "hogget ill-thrift", when it was shown that while Vitamin E gave some protection against the former condition, selenium almost completely prevented it.

In the course of this work it was observed that not only did selenium prevent muscular dystrophy in lambs but also that selenium-treated lambs showed a highly significant weight gain compared with untreated controls. It was particularly noticeable in areas where considerable trouble had previously been experienced in rearing hoggets and lambs. This in turn was suggestive that selenium deficiency might also be in part responsible for the debilitating disease "hogget ill-thrift" which causes considerable loss of production on many New Zealand farms.

Further selenium trials were therefore carried out on "hogget ill-thrift" areas, but this time where white muscle disease was absent. Here, however, the weight gain response, though present to some extent, was found not to be as much as in the white muscle disease areas. This interesting point is being pursued.

Facial eczema has for many years been a disorder of great economic importance in parts of New Zealand. It was known to result from grazing in certain pastures but the toxic principle responsible for the characteristic hepatic lesions and photosensitivity eluded isolation. In 1958-59, however, a breakthrough was made with the discovery that the spores of the fungus *Sporidesmium bakeri*, present on affected pastures, contained it in high concentration. Pure cultures of the fungus produced characteristic liver damage in guinea-pigs and lambs.

The problem of how best to prevent toxicity from the fungus is under examination. Various treatments of the pastures *e.g.* harrowing, mowing, liming, application of fungicides, etc., have so far had no effect on fungus abundance. The possibility of preparing a vaccine which will protect against the fungus is now being studied.

XUM

Epididymitis of rams caused by *Brucella ovis* infection is now countered by vaccination; this is proving very satisfactory. Strain 19 is used to enhance the efficacy of the *Br. ovis* adjuvant vaccine; stringent tests have discredited the risk of the S. 19 inducing genital infection. Vaccination trials with ewes exposed to natural infection with *Br. ovis* showed that the lambing percentage of immunised ewes was significantly higher than in controls.

Vaccination against vibrionic abortion in ewes was shown to afford a significant degree of protection against challenge with cultures of *V. fetus;* tests of the vaccine are being continued.

Several instances of sheep dying after being dosed with phenothiazine have been observed. Although field evidence suggested that the phenothiazine was directly responsible trials conducted over 3 years have consistently failed to reproduce the condition, even with a 10-fold dose and under severe conditions of dehydration.

Breeding and nutrition projects were also carried out with cattle, using as far as possible sets of identical twins in order to eliminate errors due to genetical variations and make-up. This identical twin procedure was also used to test milking machines and the effects of different milking techniques on the production of dairy cows.

Six Polled Hereford bulls were selected on a basis of heat tolerance tests for use under tropical conditions in Samoa. It will be interesting to see how they fare under the actual conditions.

In connexion with cattle disease vaccination trials were carried out against vibriosis; a virus believed to be responsible for infectious bovine rhinotracheitis—blood tests indicate that the disease is widespread in New Zealand—was isolated; and a disease similar to "mucosal disease" in the U.S. and the U.K. was investigated.

Work with pigs included performance tests, breeding to eliminate "black-spotting" in Large Whites, and investigations into the mode of inheritance of diverticulosis.

The Report concludes with some comments on work done with trace elements, rabbit poisons and fungicides, and a list of over 100 publications by members of the Division during the period under review. W.E.L.

News and Comment

"DOPING" ENQUIRY BY THE JOCKEY CLUB

Dr. W. R. Wooldridge is a member of the three-man committee which has just been set up by the Jockey Club to review the rules and procedures dealing with the administration of "dope" drugs to race-horses. The other two members are the Duke of Norfolk, chairman, and Sir Laurence Byrne.

The committee has been asked to inquire into the efficiency of the present methods and alternative methods of detecting the presence of drugs, or the use of drugs on race-horses tending to affect their speed in races. They will also look into the efficiency of the present rules of racing on the subject.

The committee is asked to report, with recommendations, by the end of next March, shortly after the start of the flat racing season.

The Duke of Norfolk is a former Senior Steward of the Jockey Club, and Sir Laurence Byrne a former High Court judge.

COLONIAL RESEARCH GRANTS

Colonial Development grants for research totalling nearly £2¼ million were approved in the year ending June, 1960, the Colonial Office reported last Tuesday. More than 130 new and 82 supplementary research schemes were set up.

Of the allocation in 1959-60, about 43 per cent. was for agricultural, animal health and forestry schemes. The next highest proportion was 24 per cent. for pesticides research and nearly 16 per cent. was devoted to medical research.

New projects overseas include a contribution of £55,506 towards the recurrent costs of the Wellcome Institute for research on foot-and-mouth disease in Kenya.

LIVERPOOL VETERINARY INVESTIGATION CENTRE

We are advised from the Ministry of Agriculture, Fisheries and Food, that during the period December 24th to January 7th the Liverpool Veterinary Investigation Centre will be closed, when the staff will be involved in a move to new premises. The new address will then be:—

Ministry of Agriculture, Fisheries & Food,
Veterinary Investigation Centre,
Vine Street,
Liverpool, 7.

There will also be a change of telephone number to ROYal 5848/9.

UNIVERSITY NEWS

Cambridge

The Michaelmas term which has just ended, has been noteworthy for several reasons. The number of students who, after completing their pre-clinical courses, have come on to the School to start their clinical work, is the largest so far. There are also 16 research students reading for the Ph.D degree, including 5 from Australia, 1 from South Africa, 2 from Egypt and 1 from Ceylon. Attached workers (6) include Dr. B. Salkind from Uruguay, who holds a British Council scholarship and is receiving training in tissue culture techniques.

New appointments to the staff are Dr. R. V. Short, B.V.SC. (Bristol), M.SC. (Wisconsin), PH.D. (Cantab), as University lecturer in Animal Health: Dr. A. C. Palmer, M.A., PH.D. (Cantab), who specialises in neurology, as an Assistant Director of Research, and Mr. P. J. McCosker, formerly lecturer in the Department of Animal Husbandry, University of Queensland

Veterinary School, as a University Demonstrator in Veterinary Medicine (Clinical Pathology).

During the earlier part of the term Dr. E. J. L. Soulsby spent 6 weeks in the U.S.A. and delivered lectures at several Universities on Immunity to Parasites, under the auspices of the American Institute of Biological Sciences. Colonel Hickman has visited the U.S.S.R. during his Sabbatical leave. Dr. R. V. Short, who has been awarded a "Lalor Foundation Fellowship," is on 6 months' leave of absence, during which he is working at the Sloan-Kettering Cancer Research Institute, New York.

PERSONAL

The President of the B.V.A., Mr. Sydney Jennings, was "guest of the week" in the B.B.C. Woman's Hour programme on Wednesday last.

The Chief Veterinary Officer, Mr. J. N. Ritchie, C.B., took part in a television discussion on the slaughter policy for foot-and-mouth disease, which was broadcast in the Panorama feature last Monday. His many friends must have been very happy to see how well Mr. Ritchie looked after his recnt illness.

Dr. W. R. Wooldridge has been elected one of the first Fellows of Birkbeck College, London. The Governors, having decided to institute honorary Fellowships elected the following:—

Lord Denning; Professor Dame Helen Gwynne-Vaughan; Professor Dame Lillian Penson; Professor Sir Albert Richardson; Mr. H. G. Richardson; Professor Eva G. R. Taylor; and Dr. W. R. Wooldridge.

Births

DORAN.—On November 27th, 1960, to Jeannine, wife of G. P. Doran, B.V.SC., M.R.C.V.S., The Orchard House, Alveston, Glos., a daughter, Camilla, sister for Anita, Susanne, and Rowena.

WIGHT.—At Craigtoun Hospital, St. Andrews, on November 27th, 1960, to Frances, wife of Graham Wight, B.SC., M.R.C.V.S., "Kallada," Auchtermuchty, Fife, a daughter.

YEATS.—On November 8th, 1960, to Kathleen (*née* White), wife of John J. Yeats, M.R.C.V.S., of Saxon Place, Langford, a daughter, Sarah Fiona, sister for Richard.

CLASSIFIED ADVERTISEMENTS

Will readers kindly note that having regard to the Christmas vacation, classified advertisements intended for our December 24th issue must be received by first post Monday, December 19th. Advertisements intended for December 31st must be received by Wednesday, December 21st.

COMING EVENTS

December

11th (Sun.). SOUTH EAST MIDLANDS VETERINARY ASSOCIATION. Joint meeting with the Kettering and District Medical Society at the George Hotel, Kettering, 7 p.m.

14th (Wed.). SUSSEX VETERINARY SOCIETY. Meeting at the Old Ship Hotel, Brighton, 2.30 p.m.

WEST OF SCOTLAND DIVISION. Meeting at the University Veterinary Hospital, Bearsden, 7.30 p.m.

B.S.A.V.A. NORTH EASTERN REGION. Meeting at the Queen's Hotel, Leeds, 1, 8 p.m.

15th (Thurs.). WESTERN COUNTIES VETERINARY ASSOCIATION. Meeting at the Rougemont Hotel, Exeter, 2.30 p.m.

SOUTH EASTERN VETERINARY ASSOCIATION. Meeting at the Royal Star Hotel, Maidstone, 2.30 p.m.

THE ASSOCIATION OF VETERINARY STUDENTS

The Annual Conference of the Association will be held in New Brighton, Wallasey, from January 20th to 22nd, 1961. The Liverpool University Veterinary Society will be acting as host. The programme will be as follows:—

Friday, January 20th.

10 a.m. Official opening in Wallasey Town Hall by Mr. G. N. Gould, senior Vice-President of the Royal College of Veterinary Surgeons.

11 a.m. Symposium and discussion—"The Veterinary Profession, Past, Present and Future." Speakers: Mr. J. W. Barber-Lomax, Mr. L. G. Anderson, Professor J. G. Wright.

2 p.m. Commercial visits, films and sports.

8 p.m. Dance in the Students' Union, Liverpool.

Saturday, January 21st.

Visit to the University of Liverpool Veterinary Field Station, Leahurst. Closed-circuit T.V. surgery demonstration. Tour of the new veterinary building.

Sunday, January 22nd.

11 a.m. A.G.M. in Wallasey Town Hall.

1.30 p.m. Visits to Chester Zoo and Great House Experimental Husbandry Farm, Rossendale.

ADDRESSES OF DISEASE INFECTED PREMISES

The list given below indicates, first the county in which are situated the premises on which disease has been confirmed, followed by the postal address and date of outbreak.

Anthrax

Leics. Bryces Barn Farm, Croxton Kerrial, Harston (Dec. 2).

Perth. Balnadrum Farm, Pitlochry (Dec. 2).

Renfrew. Whitemoss Farm, Erskine, Bishopton (Dec. 1).

Salop. Lower House Farm, Ridge, Ellesmore (Dec. 2).

Foot-and-Mouth Disease

Aberdeen. Nether Kirkton, Dyce; Little Aucheock, Maud (Nov. 30); Lochter, Old Meldrum (Dec. 1); Stoneygate Farm, Hatton (Dec. 3); Middleton of Scotstown, Bridge of Don (Dec. 4).

Fife. New Carden, Cardendedn; Grange Farm, Burntisland (Dec. 2).

Norfolk. Calthorpe Farm, Ingham, Norwich (Dec. 4).

Northumberland. South East Farm, Berwick Hill, Ponteland, Newcastle upon Tyne (Nov. 29); Bavington Mount, Capheaton, Newcastle upon Tyne (Nov. 30).

Notts. Yew Tree Farm, Aerodrome Site, Elkesley, Retford (Dec. 1); Lower Hexgrave Farm, Farnsfield, Newark; South Farm, Budby, Ollerton, Newark (Dec. 2).

Orkney. Valdigar Farm, Tankerness, Kirkwall; Mowatt Lower Disgarth, Evie, Kirkwall (Dec. 1); Sebay Farm, Tankerness, Kirkwall (Dec. 3).

Salop. No. 6 Holding, Hatton Hinstock, Market Drayton; The Laurels, Ollerton, Market Drayton (Nov. 29).

Fowl Pest

Essex. Clayton Stores, Norksmill Road, Billericay (Nov. 29); Berghott House, Lower Dunton Road, Horndon-on-the-Hill, Stanford-le-Hope; Tarrum, Gordon Road, Horndon-on-the-Hill, Stanford-le-Hope (Nov. 30).

Middlesex. 15 Bedfont Court Estate, Stanwell Moor, Staines (Dec. 1).

Norfolk. Old Hall Farm, Bodley Moor, Dereham; 12 High Street, Littleshall, Kings Lynn; Burland Green, Forncett St. Peter, Norwich; Harewick Hall, Norwich; Nut Tree Farm, Redenhall, Harleston; North Green, Pulham St. Mary, Diss; Blackmoor Row, Shipham, Thetford (Nov. 29); Home Farm, Barnham Broom, Norwich; Hall Farm, Boughton, Stoke Ferry, King's Lynn; Oxen House, Themelthorpe, Dereham; Fersfield Aerodrome, Winfarthing, Diss; 18 Crown Road, Derenam; Boughton Manor Farm, Starston, Harleston; Hudsons Farm, Starston, Harleston; Red House Farm, Starston, Harleston; Cherry Dene Farm, Beccles Road, Bradwell, Gt. Yarmouth; Hundred Bound Farm, Starston, Harleston; Portwood Farm, Attleborough; King Street, New Buckenham, Norwich; Clay Lane, Haveringland, Norwich; Star Farm, Bradwell, Great Yarmouth; Morningthorpe Farm, Hardwick, Long Stratton, Norwich; Park Farm, Rocklands, Attleborough; Corner Farm, Rocklands, Attleborough (Nov. 30); Kemps Lane, Hockwold, Thetford; White Horse Street, Wymondham; Villa Farm, Alburgh, Harleston; Beech Cottage, Norwich Road, New Buckenham, Norwich; Walnut Tree Farm, Caston, Rocklands, Attleborough; Black Farm, Hardwick Road, Starston, Harleston (Dec. 1); Rush Farm, Forncett St. Peter, Norwich; Brook Farm, North Green, Pulham St. Mary, Diss; Gibraltor Farm, Hingham, Norwich; Hall Farm, Caston, Attleborough; The Limes, Ollands Road, Reepham, Norwich; 13 School Road, Buckenham, Norwich; The Old Rectory, Buckenham, Norwich; Bowers Farm, Rocklands, Attleborough; Carlton Rode, Norwich; East Caister Poultry Site, Ormesby, Great Yarmouth (Dec. 2); School Farm, Scoulton, Norwich; Burlingham Lodge, Denton, Harleston; Morley Old Hall, Morley St. Peter; Church Farm, Sisland, Loddon, Norwich (Dec. 3); Mill Street, Buxton, Norwich; Hackford Road, Hardingham; Rookery Farm, Rockland All Saints, Attleborough; Grange Farm, Hardwick, Norwich; Wayford House, Stalham, Norwich; North Green, Pulham St. Mary, Diss; Rookery Villa, Thuxton, Dereham; Olland Road Allotments, Reepham, Norwich (Dec. 4).

Notts. 4 Mina Street, Sutton-on-Trent, Newark; Holmewood, Sutton-on-Trent, Southwell (Dec. 1); Mount Pleasant Farm, Sutton-on-Trent, Newark (Dec. 2); Ingram Lane, Sutton-on-Trent, Newark, (Dec. 3).

Somerset. Linden, Limmington, Yeovil (Nov. 30).

Suffolk. South Stack, Fornham All Saints, Bury St. Edmunds; Green Farm, Yoxford, Saxmundham (Nov. 29); 14 Fornham Road, Bury St. Edmunds; 37 Avenue Approach, Bury St. Edmunds (Nov. 30); The Grange Flixton, Bungay (Dec. 1); Timworth Hall Farm, Timworth, Bury St. Edmunds; North End, Exning, Newmarket; Pakenham Manor, Pakenham, Bury St. Edmunds; Woodlands, Topcraft, Bungay; Little Manor Farm, Topcroft, Bungay (Dec. 2); The Gables, Topcroft, Bungay; The Rookery Woodyard, Town Street, Brandon (Dec. 3).

Sussex. Restlands, Nutley, Uckfield (Dec 2).

Swine Fever

Ches. Lane End Farm, Ashton (Nov. 30); Morley Hall Farm, Little Barrow (Dec. 1).

Denbigh. Penrhiw Isaf, Glan Conway (Dec. 2).

Devon. Whitehouse Farm, Winkleigh (Nov. 30); Brendon, Halwill, Hatherleigh; Okehampton (Dec. 2).

Kent. Potlen Farm, Bethersden, Ashford (Nov. 29); Piggeries, Birchwood Farm, Biddenden, Ashford (Nov. 30).

Lancs. 12 Vicarage Lane, Banks, Southport (Nov. 29); Morrs Farm, Hambleton, Blackpool (Nov. 30); Forest Farm, Elswick, Preston (Dec. 2).

Lincs. Elsham Top Farm, Elsham, Brigg (Dec. 1).

Norfolk. Mill Pond Farm, Garboldisham, Diss (Nov. 29); Elmerdale Cottages, Saxthorpe, Corpusty, Norwich (Nov. 30).

Northants. Manor House Farm, Ailsworth, Peterborough (Nov. 29).

Salop. The Hollies, Ratlinghope, Shrewsbury (Nov. 30).

Suffolk. Rookery Farm, Ilketshall St. Andrew, Beccles (Dec. 1).

Yorks. Kellwell Farm, Swine, Hull; Whitehouse Farm, Salterforth, Colne (Nov. 29); Stockton Cottage Farm, Huntington; Ellerton North Farm, Ellerton-on-Swale, Scorton, Richmond (Dec. 1); Dalton Grange, Dalton, Richmond; West Riding Piggeries, Hutton Hill, Ripon (Dec. 2).

THE BETTING LEVY BILL

Members of the Association will have read in the newspapers that the Betting Levy Bill, which followed the findings of the Peppiatt Committee (to which the B.V.A. gave evidence), passed its second reading on December 5th. In welcoming the Bill, Mr. Peart said:—

"I have here a communication from the British Veterinary Association giving details of what is needed in relation to veterinary education and research. It is accepted that more money is required in many branches of veterinary science dealing specifically with the horse. It is not sufficient to give money for veterinary education and science, it must be specifically related to solving the problems of horse breeders, and for equine research. This is something which should have careful consideration because, originally, when money was farmed out to veterinary establishments—the proceeds from the Totalisator Charity Trust, etc.—most of it was given for veterinary education generally. I want money to be farmed out specifically for veterinary research concerned with the horse and problems arising therefrom. I have a list of the things urgently required and how we need more scholarships and fellowships for investigation into veterinary problems concerning the horse. They have been outlined by the British Veterinary Association. We wish to see money which the Levy Board collects used properly and for specific research which is important."

In the course of his remarks Mr. Peart also said that he thought it necessary to have a check on the Levy Board. If there were one representative from the Jockey Club, there could be a representative from the Royal College of Veterinary Surgeons, or if necessary an independent member. These were the people concerned with the main purposes of the Bill.

THE ROYAL COLLEGE OF VETERINARY SURGEONS

Temporary Building

The present office of the College at Red Lion Square will be closed at 5 p.m. on the evening of Thursday, December 29th, and will re-open at the new temporary address—College House, Wright's Lane, Kensington, W.8.—on Monday, January 2nd, 1961, at 9.30 a.m.

It is asked that enquiries and correspondence may be kept to the minimum during the week immediately before and after the move.

Wright's Lane runs south from Kensington High Street along the side of Messrs. Pontings. College House is a modern office block on the left towards the bottom of Wright's Lane, when approaching from Kensington High Street. The College accommodation will be on the first floor. Kensington High Street Station (District and Circle lines) is immediately adjacent to the temporary College building.

Letters to the Editor

The views expressed in letters addressed to the Editor represent the personal opinions of the writer only and their publication does not imply endorsement by the B.V.A.

Veterinary Education

Sir,—I have followed the correspondence on veterinary education with great interest, but have been disappointed to see little mention of extramural tuition so far. As Mr. B. F. Bell has pointed out, many practising veterinary surgeons have knowledge that is of great value to students, but surely the best place for them to impart their knowledge and experience is in the field, *i.e.* to the student who is "seeing practice"? Many veterinary surgeons who lack the time, and in some cases the ability, to give lectures or write papers are excellent informal teachers and seize the opportunity of familiarising the student with practical procedures and techniques which it is often claimed they fail to acquire at the veterinary schools.

I feel sure that "seeing practice" is an invaluable adjunct to formal education, and it is interesting to note that the medical profession is considering the adoption of a similar system for medical students.

Students can be, and no doubt are, encouraged to see an adequate amount of practice by the provision of up to date, informative details of practices willing to take them. If necessary, perhaps an appeal could be made to those veterinary surgeons who have not hitherto taken students to do so, if possible.

Also, may I suggest that the benefits of extra mural tuition are not confined solely to the student? Many veterinary surgeons may derive considerable interest from contact with young enquiring minds, and feel satisfaction in helping to ensure that newly qualified assistants will be of more immediate practical help to their principals.

Lastly, but by no means least, it is largely whilst seeing practice that the student will receive his introduction to the very necessary art of gaining the confidence and co-operation of the owner of the patient.

It would be most interesting to hear the views of members of the profession on the subject of extramural tuition.

Yours faithfully,

61, Laurel Way, DEIRDRE M. MILNES.
Totteridge, London, N.20. *November 28th*, 1960.

Studies in Anaemia in Pigs

Sir,—Am I alone in believing that experimentation at public expense of the kind recorded in the above report (*Vet. Rec.* **72.** 1,028) should be unacceptable in the absence of veterinary collaboration in the work no matter how eminent the authors? Certainly the statement, "there was no indication that this casualty rate was influenced by the applied treatments" appears to require confirmation by a recognised authority on animal disease to be of value.

Unfortunately, the Shinfield group is by no means alone in overlooking the value of a veterinary colleague, as the build up of a "self-sufficient in animal work" attitude, sometimes accompanied by open antagonism to so called interference by the "vet.," is common in graduates and even diploma holders in agriculture as personal experience and examination of programmes of work show.

Does the final sentence of the report concerning variation in the animal's point to further scope for a veterinary member of the team? No supporting evidence here for the "like as peas in a pod" litters of the pig enthusiast—oh! dear, what could have gone wrong?

Yours faithfully,

Bieldside, JOHN C. GRANT.
Aberdeen. *November 22nd*, 1960.

Preputial Catarrh in the Dog

Sir,—We have recently investigated a few cases of preputial catarrh in the dog.

Whilst pus cells have been seen, we have not yet succeeded in growing any bacterial or fungal pathogen, and wonder if others have had similar experiences.

Many practitioners must have been presented with patients suffering from a copious preputial discharge, which is usually cream or greenish in colour. Whilst this does not appear to have any detrimental effect upon the animal, it is a source of embarrassment to the owner, and one is asked to treat the condition.

We have been singularly unsuccessful in treating it with any of the recognised medicaments, but have had a marked success when using hexetidine.*

Hexetidine (0.5 per cent.) is diluted 1:10 with tepid water, and by means of a Higginson's syringe, the prepuce is thoroughly douched on 2 to 3 successive days.

We should be interested to hear if others have been able to isolate a causal pathogen in similar cases, as the response to hexetidine would indicate that the condition may be mycotic in origin.

Yours faithfully,

36 Whatley Road, A. H. LINTON,
Clifton, G. SUMNER-SMITH.
Bristol, 8. *December 3rd*, 1960.

* Hexocil, William R. Warner & Co., Ltd.

Solids-not-fat Content of Cows' Milk

Sir,—In his review of factors affecting the solids-not-fat content of cows' milk (*Vet. Rec.* November 5th), Dr. J. O. L. King refers briefly to the possibility that "a short period of feeding a thyroid activating material, such as iodinated casein, might be useful in March when milk quality tends to be low."

Although, strictly speaking, iodinated casein is not thyroid *activating*, Dr. King's suggestion is in marked contrast to the attitude of the Cook Committee who dismiss the subject in their recent report† with the perfunctory (and inaccurate) statement that "the use of thyrotropic hormones to promote milk secretion is a thing of the past."

The application of thyro-active substances in farming is restricted, not so much because of risk

† "Milk composition in the U.K." Report of an Interdepartmental Committee. Cmnd. 1147 (1960), London: H.M.S.O.

XUM

to animals, which is small, or to humans, which is non-existent, but on the ground of uncertain economic return. Nevertheless these materials are available and their potential use is supported by a rapidly growing literature of more than 700 scientific papers.

Many farmers could, in all probability, avoid the penalty for production of low-fat milk by short period use of a thyroid hormone preparation in order to break a sequence of unfavourable tests. Various other possibilities exist for both use, and abuse, of these materials; applications in pig husbandry are perhaps greater than with cattle.

The present need is that conditions of use for optimum effect and profitability should be established, together with some measure of restriction and control. From all points of view it seems desirable that the veterinary profession should provide the lead.

Yours faithfully,
G. CALDERBANK.

Chilean Iodine Educational Bureau,
Chile House,
20-24 Ropemaker Street,
London, E.C.2.
November 30th, 1960.

Holiday Lectures

Sir,—Children's holiday lectures are given annually in London at this time of year by such institutions as the British Museum, Institution of Civil Engineers, The Iveagh Bequest, The Royal College of Surgeons, The Royal Geographical Society, The Tate Gallery and the Zoological Society of London to mention only a few, and prove a popular diversion for school children as well as enabling them to obtain a broader understanding of the various arts, sciences and professions. Would it not be possible for one of our senior institutions such as the Royal Veterinary College, or the Royal College of Veterinary Surgeons when it gets its new home, to organise a series of lectures or demonstrations for the young in the winter vacations?

I have no doubt such lectures would be immensely popular, and would perhaps create a fund of goodwill towards the profession as well as removing some of the misconceptions that laymen sometimes have about us.

Yours faithfully,
P. N. HUMPHREYS.

8 Railway Street,
Newport,
Mon.
November 28th, 1960.

Treatment of Cat Influenza

Sir,—Far be it from me to presume to enter your columns as a scientist; but during the latter months of my sojourn in the British Islands I made what was, to me, a singular observation.

It is well known that all species show good response to cortisone therapy, not only to reduce both chronic and acute inflammations, but also (coupled with the administration of antibiotics) to combat certain infectious diseases.

I have also held it well recognised throughout the profession that cat 'flu shows a remarkable resistance to antibiotic therapy of any kind, and that usually it is a matter of a week before a cat shows any keenness for repast or cessation from continual sneezing.

Working on the premise that it is the inflammatory response to the virus infection that causes the greatest part of the distress from the disease, I began administering cortisone (Prednisolone) together with penicillin with extremely gratifying results.

Not belonging to any commercial enterprise nor angling for any scholarship for research nor a minute or two on television, I do not make any extravagant claims for this therapy. I have not had 100 per cent. success; but on most occasions have been able to make a second visit to the patient without any loss of face and usually am fortified for the rest of the daily round by generous commendations from the client.

Yours faithfully,
P. N. TRIM.

18 Clifford Road,
Eltham,
Taranaki, New Zealand.
November 15th, 1960.

Anaemia in Trichostrongylid Infestations

Sir,—A B.V.A. Congress paper with this title by myself and A. C. Gardiner was the subject of comment by I. H. Pattison in a letter you published on November 26th. He charged us with misrepresentation regarding a paper written by Holman and Pattison in 1941, and the charge was specified on two grounds.

First, we expressed the opinion that one of the arguments used in their paper was "dubiously permissive." It was an argument based on an analogy between systems involving parasites from different phyla in different organs of hosts from different orders. (*Diphyllobothrium latum* in the small intestine of man and *Haemonchus contortus* in the ruminant abomasum.) Analogy lacks the compulsiveness of logic and this one is too tenuous to be persuasive. Your correspondent may feel it irksome that we should remain unconvinced but he cannot hold that this constitutes misrepresentation.

Secondly, in our review we presumed no more than to express our adherence to the opinion to which his results led Fourie in 1931, and with which several authors have since concurred. We wrote, "against this apparently well established case Holman and Pattison (1941) have registered a note of dissent," and we quoted their main conclusion verbatim indicating that they admitted the partial applicability of Fourie's views. Nevertheless, we are accused of having inferred a failure by your correspondent and his co-author to "consider (and discard) the hypothesis advanced by the Campbell-Gardiner school." I suggest that the school and its hypothesis are creations of your correspondent's imagination.

On both counts we reject the charge of misrepresentation. Indeed, who is misrepresenting whom? Had your correspondent read what we wrote he would not have needed to deny that he "sought to disrepute (*sic*) Fourie's findings" since the word used was "dispute."

The remaining and major part of your correspondent's letter is unworthy of reply. He is entitled to his opinions but whether they are germane, or their expression was justified, must be decided by reference to what our text contains in fact.

Yours faithfully,
J. ALLAN CAMPBELL.

Animal Disease Research Association,
Moredun Institute,
Gilmerton,
Edinburgh, 9.
November 29th, 1960.

Sir,—It is regrettable that the erroneous printing of "disrepute" for "dispute" referred to in your issue of December 3rd should have led me to accuse Mr. I. H. Pattison of misrepresentation. For this I apologise. I suggest, however, that, in spite of its quaint grammatical usage, the misquotation made sense in its context whereas your correspondent's denial that he and his co-author "sought to dispute Fourie's findings" is not, in my opinion, consonant with the facts.

Yours faithfully,
J. ALLAN CAMPBELL.

December 5th, 1960.

Dictyocaulus arnfieldi Infestation in Horses

Sir,—The apparent rarity, or failure to recognise, the above condition and the similarity of signs to those of infectious equine cough as described by Mr. Wm. C. Miller, in a letter to the Editor (*Veterinary Record*, October 29th, 1960), and a summary of the report by O. Waldmann and K. Klöbe (letter to the Editor, *Veterinary Record*, November 19th, 1960), prompt me to record the results of an investigation carried out at a small riding school this autumn.

A 10-year-old hunter "A" had suffered from a deep, convulsive cough since May, 1960, which had been treated with electuary and linctus to no avail. At no time was a rise in temperature found and auscultation of the chest revealed nothing until mid-September when slight vesicular sounds were heard. On or about September 20th, a 9-year-old polo pony "B" developed a cough, again with no rise in temperature and no audible abnormalities, though the cough in this case was rather shallow and dry. Dung samples were taken and penicillin and streptomycin given intramuscularly for 3 days, by which time "A's" cough had become much less frequent, dry and shallow. Examination of both samples, by The Veterinary Investigation Centre, Langford House, Lower Langford, Bristol, revealed the presence of *Dictyocaulus arnfieldi* larvae.

Following on these results, dung samples were taken from 6 other hunters and polo ponies at the School; of these, 4, from two 9-year-old hunters "C" and "D" and two 6-year-old hunters "E" and "F" showed the presence of lungworm larvae. Dung samples were taken from 2 other animals, on October 17th and 20th and showed no evidence of larvae.

The source of infestation has been hard to determine; "A" and "C" were at grass in an orchard at the School until stabled in mid-September, "B" was grazing on low-lying pasture until being housed at the same time, "E" was purchased from another riding school in May, 1960, and had been stabled ever since, "D" was on loan from a trainer and had been stabled from the time he came to the School, and "F" was brought from a dealer in June and had been stabled since then. The only likely source was thought to be from herbage growing round the "lines" at which the horses were tied on the polo field.

Five of the animals which showed evidence of infestation were dosed with diethylcarbamazine citrate,* 100 c.c. daily in the drinking water for 3 days, starting on or about October 12th; the sixth animal "D" had been returned to the trainer. Dung samples taken on October 26th and examined by Burroughs Wellcome, were all negative.

In the Spring of this year one animal, an aged polo pony, developed acute pulmonary emphysema and was subsequently destroyed. No *post-mortem* examination was carried out, as at the time the lungworm infestation at the School was not appreciated.

Two quite unsubstantiated but interesting points arise. There is a possibility of "reinfestation phenomena" producing a cough in immune horses without the production of larvae. The aetiology of "broken wind" has not, to my knowledge, been satisfactorily explained.

I wish to thank the Veterinary Investigation Centre, Langford House, Lower Langford, Bristol for their examination of dung samples submitted and Messrs. Burroughs Wellcome for the supplies of "Franocide."

Yours faithfully,
R. B. FLETCHER.

"Melrose,"
Coursing Batch,
Glastonbury,
Somerset.
November 30th, 1960.

* Franocide, Burroughs Wellcome.

Diet and Bovine Fertility

Sir,—Littlejohn and Lewis (1960) have recently demonstrated that bovine fertility was not affected by the Ca and P content of the diet. This work was based on Ca and P supplementation of a basal diet. Their findings are in disagreement with Hignett's work, who considered a high calcium diet and increased Ca and P ratio to be factors reducing bovine fertility (Hignett, 1950). The latter worker pointed to the shifting pattern of infertility in cattle which is associated with an increase in ovarian dysfunction and cystic ovaries. This shift he associated with the change in management procedures and increased liming of pastures which implied an increase in high calcium-retaining plants, primarily legumes.

We recently investigated a syndrome associated with infertility which we consider to be hyperoestrogenic in nature (Adler & Trainin, 1960). This conclusion was arrived at in view of the high frequency of ovarian cysts, oestrus in pregnant cows, enlarged mammary glands, all occurring in unbred heifers. The syndrome was traced to alfalfa feeding and the alfalfa in question was found to contain oestrogenic activity. Further evidence that alfalfa may

contain oestrogens in sufficient quantity to have a pharmacological effect on cattle is presented by Matsushima (1960) (quoted by Bickoff *et al.*), who showed that alfalfa feeding had an effect similar to stilboestrol on weight gain in steers.

In the past, cattle in the Jordan Valley had a consistently lower conception rate than cattle in other parts of the country. Since water is plentiful in this region, heavy alfalfa feeding of the cattle was customary. Foltin (1954) associated the reduced fertility with a syndrome involving ovarian dysfunction and cystic ovaries. He considered the problem to be related to heavy alfalfa feeding.

Both our cases and Foltin's observations could be correlated with a high Ca intake associated with alfalfa feeding. A diet high in calcium, when Ca supplements are excluded, implies a high proportion of legumes in the food.

Thus calcium may have served as an index to oestrogenic activity which is common in leguminous plants.

Yours faithfully,

J. H. ADLER,
Dept. of Physiology, Veterinary Institute, Rishon-le-Zion.
D. TRAININ,
Hahaklait, Givatayim.
Ministry of Agriculture Veterinary Institute,
P.O.B. 12 Beith Dagan, Israel.
November 30th, 1960.

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Small Animal Radiography

Sir,—I should like to congratulate Mr. Donald Lawson on his very clear and lucid paper on "Small Animal Radiography," particularly on the able way in which he divided his subject up and the emphasis placed on the various points of importance.

However, one criticism I should like to voice, as a user of one of these small portable machines (developing 55 to 60 kV.) for over 20 years, is that Table III gives the impression that most of the exposures using 10 M.A. or even 15 M.A. would be at 1 second or even longer. With intensifying screens in lead-backed cassettes, fast film and a reduction in distance between object and X-ray source (with a fine focal spot) excellent films of good diagnostic quality can be obtained of the majority of small animals.

Large dogs, I know, require apparatus of higher kV.; but even in these cases accurate positioning, a compression band and the use of anaesthesia can be of great aid. Incidentally, small sandbags and light stands with carpentry screw clamps for holding X-ray cassettes in place can help minimise human exposure, and ensure accurate positioning of the film.

I see no mention was made of the insufflation of air into the bladder, which is quite a useful procedure. Nor was a time quoted for the X-raying of the abdomen following the administration of barium meal. Times used here are as follows:—

To outline the oesophagus, using very thick barium suspension, 2 to 5 to 10 minutes.

To outline the stomach using standard suspension or mixed with meat, within half an hour.

To outline the small intestine (duodenum and jejunum) half to one hour.

To outline the small intestine and large colon, 2 to 4 hours.

However, the necessity of these procedures is by no means as frequent as in the human subject.

In conclusion, may I again say how interesting I found Mr. Lawson's paper, and that my remarks are not made in a spirit of carping criticism, but rather with the feeling of disappointment I was not present at the reading of the paper.

Yours faithfully,

DONALD BALLS.
St. Brelades,
Knoll Road,
Dorking.
December 5th, 1960.

How Not to Write to Colleagues

Sir,—Telephone enquiries aside, I am in receipt of many hundreds of letters over the course of the year from veterinary surgeons, requesting help and advice with regard to the treatment of exotic pets. I am always happy to do my best to assist.

What does not give me pleasure, however, is the appalling standard of literary merit and calligraphy of some of the letters that I receive. Many are very badly written and illegible, and there is a sad tendency for veterinary surgeons to forget—at least with regard to their letter writing—that they are all professional colleagues one of another and that the customary address and subscription is "Dear X" and "Yours sincerely."

All too frequently I am addressed as "Dear Sir," and am assured that the letter is written by "Yours faithfully," a style reserved for Editors!

I am stimulated to write this letter by one that I have received to-day which started "Dear Sir," and ended "Yours faithfully," consisted of two very short sentences, the second of which was "The bird has a tapeworm protruding from the cloaca, would you please send details of correct treatment to eliminate this."

Tell me, Sir, do you think that I am over sensitive in regarding this type of letter as an impertinent, demanding insult?

Yours faithfully,

OLIVER GRAHAM-JONES.
The Zoological Society of London,
Regent's Park,
London, N.W.1.
December 2nd, 1960.